Marine Science Affairs

—SELECTING PRIORITY PROGRAMS

Annual Report of the President to the Congress on Marine Resources and Engineering Development

April 1970

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Annual Report of the President to the Congress on Marine Resources and Engineering Development, together with the Report of the National Council on Marine Resources and Engineering Development.

April 1970

PRESIDENT'S TRANSMITTAL MESSAGE TO CONGRESS

TO THE CONGRESS OF THE UNITED STATES:

The fact that the United States is first in space is well known; it is less well known that we are also first in oceanic science and technology. And while most of our citizens recognize the opportunities which lie before us in space, fewer understand the enormous benefits which can flow from our national marine activities.

During 1969, the National Council on Marine Resources and Engineering Development, chaired by the Vice President, identified a number of policies and programs concerning the sea which, in their judgment, deserve Federal support. I am today transmitting to the Congress the Council's annual report, "Marine Science Affairs—Selecting Priority Programs." The marine science programs which I have approved for Fiscal Year 1971 are based in part on the Council's recommendations.

My budget request for Fiscal Year 1971 provides $533.1 million for marine science and technology activities. These funds would help us to improve the management of our coastal zone, expand Arctic research, develop a program for restoring damaged lakes, expand the collection of data concerning ocean and weather conditions, reduce merchant ship operating costs, and undertake other important projects. The funds would also support U.S. participation in the International Decade of Ocean Exploration, a program which can contribute much to the quality of the marine environment and to the pursuit of world peace.

In November of 1969, this Administration sent to the Congress a comprehensive proposal for protecting and developing the land and water resources of the nation's estuarine and coastal zone. I hope that the Congress will give this program early and careful attention.

The Federal government will continue to provide leadership in the nation's marine science program. But it is also important that private industry, State and local governments, academic, scientific and other institutions increase their own involvement in this important field. The public and private sectors of our society must work closely together if we are to meet the great challenges which are presented to us by the oceans of our planet.

Richard Nixon

The White House, *April 1970.*

VICE PRESIDENT'S LETTER TO THE PRESIDENT

THE VICE PRESIDENT,
Washington, D.C., April 1970.

THE PRESIDENT,
The White House,
Washington, D.C.

DEAR MR. PRESIDENT:

As Chairman of the National Council on Marine Resources and Engineering Development, I take pleasure in forwarding the Council's Annual Report, "Marine Science Affairs—Selecting Priority Programs."

The Report reviews the activities and accomplishments of all Federal departments and agencies in the field of marine sciences during 1969, and evaluates these accomplishments in terms of the objectives of the Marine Sciences Act.

Important progress has been realized in a wide range of marine science activities including research, engineering, exploration, mapping, and environmental services. Significant marine science developments, as described in the Report, have occurred in the fields of international cooperation, national security, marine resources, transportation, coastal zone management, and environmental quality preservation—reflecting the Nation's growing use of the world ocean. Federal leadership and support are important, but we must look to other sectors to carry out major roles in the national ocean program—particularly to industry for the recovery of ocean resources and to the States for the management of the coastal zone.

The Federal marine science budget has shown substantial growth from $463.4 million in Fiscal Year 1969, to $514.3 million in Fiscal Year 1970, to $533.1 million requested in your budget for Fiscal Year 1971. This request includes an increase in obligations for marine science, technology and related activities in civilian agencies of $42 million over Fiscal Year 1970.

During 1969, the Marine Sciences Council advanced from the identification of critical Government-wide marine science issues to the development of priority programs to meet national needs. The Report sets forth the priorities that have emerged in the Federal marine science program and describes the initiatives you have approved for Fiscal Year 1971 including:

—A national policy and Federal grant program to encourage States to improve planning and management of their coastal areas.

—Marine research, essential to wise use of the coastal environment.

—Lake restoration programs aimed at restoring the quality of seriously damaged national waters, including the Great Lakes.

—Arctic environmental research to permit fuller, rational use of the Arctic region.

—The International Decade of Ocean Exploration, a cooperative program with coordinated research, surveys and data sharing leading to mutually beneficial understanding of the world ocean.

—Expansion of the program to develop oceanographic and atmospheric buoys for productive multi-agency use in a broad-ranging program.

—Research and development to reduce merchant ship operating costs.

These initiatives will build on the broad base of on-going Federal activity, placing emphasis on environmental quality, wise development of the Nation's fragile, invaluable coastal zone, and meaningful international cooperation. They provide the basis for concerted action by the Federal Government, State governments, the academic community, and industry to meet the Nation's priority oceanic objectives.

Sincerely,

Spiro T. Agnew

PREFACE

A Report to the President From the National Council on Marine Resources and Engineering Development, April 1970

This Report to the President on Marine Science Affairs is prepared in accordance with Public Law 89–454, the Marine Resources and Engineering Development Act of 1966, which states that the President shall transmit to the Congress an annual report including (a) a comprehensive description of the activities and the accomplishments of all the agencies and departments of the United States in the field of marine sciences during the preceding fiscal year, (b) an evaluation of such activities in terms of the objectives set forth pursuant to Public Law 89–454, (c) such recommendations for legislation as the President may consider necessary or desirable for the attainment of the objectives of Public Law 89–454; and (d) an estimate of funding requirements of each agency and department of the Federal Government for marine science activities during the succeeding fiscal year.

The Marine Resources and Engineering Development Act was amended by Public Law 89–688, the National Sea Grant College and Program Act of 1966, which also requires an annual report by the President on Sea Grant colleges and programs.

This Report on Marine Science Affairs is submitted to the Congress in response to both requirements. It was prepared by the National Council on Marine Resources and Engineering Development. The Council, located in the Executive Office of the President, is composed of:

CHAIRMAN:

Spiro T. Agnew, *the Vice President*

MEMBERS:

William P. Rogers, *the Secretary of State*
John H. Chafee, *the Secretary of the Navy*
Walter J. Hickel, *the Secretary of the Interior*
Maurice H. Stans, *the Secretary of Commerce*
Robert H. Finch, *the Secretary of Health, Education, and Welfare*
John A. Volpe, *the Secretary of Transportation*
Glenn T. Seaborg, *Chairman, Atomic Energy Commission*
William D. McElroy, *Director, National Science Foundation*

OBSERVERS:

Thomas O. Paine, *Administrator, National Aeronautics and Space Administration*
S. Dillon Ripley, *Secretary, Smithsonian Institution*
John A. Hannah, *Administrator, Agency for International Development*
Robert P. Mayo, *Director, Bureau of the Budget*
Paul W. McCracken, *Chairman, Council of Economic Advisors*
Lee A. DuBridge, *Director, Office of Science and Technology*

EXECUTIVE SECRETARY:

E. L. Dillon, Acting
(Edward Wenk, Jr., until January 31, 1970)

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INTRODUCTION

With the enactment of the Marine Resources and Engineering Development Act of June 17, 1966, increased Federal attention was focused on marine science affairs. Clear recognition of oceanic potential, problems and goals is reflected in the Act's statement of national purpose: "It is hereby declared to be the policy of the United States to develop, encourage, and maintain a coordinated, comprehensive, and long-range national program in marine science for the benefit of mankind to assist in the protection of health and property, enhancement of commerce, transportation, and national security, rehabilitation of our commercial fisheries, and increased utilization of these and other resources."

The Marine Sciences Act [1] provided—

(1) A new emphasis on Presidential leadership;

(2) An interim Cabinet-level Council, chaired by the Vice President, to assist the President in policy development and coordination of the Federal marine sciences program; and

(3) An interim public advisory Commission to identify the Nation's stake in the oceans and to recommend future steps for the national program.

The Act also gave the President responsibility for implementing the legislation by—

(1) Developing a comprehensive marine science program involving Federal agencies working in cooperation with the entire spectrum of non-Federal organizations including State and local governments, private research institutions, and industry;

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[1] Following are some abbreviations and definitions in use in the marine sciences field:

The Act is customarily called the Marine Sciences Act. See app. B–2 for its full text.

The National Council on Marine Resources and Engineering Development is usually abbreviated to the Marine Sciences Council.

The Commission on Marine Science, Engineering, and Resources, no longer in existence, is usually referred to as the Marine Sciences Commission.

"Marine science" is a term employed in Public Law 89–454, sec. 8, to describe scientific research, engineering, and technological development related to the marine environment.

The "marine environment" is considered to include the oceans, the Continental Shelf, seabed and subsoil of submarine areas and resources thereof, and estuaries of the United States and its territories, the Great Lakes, and the resources of the ocean and Great Lakes.

(2) Conducting long-range studies of the potential benefits to our economy, security, health, and welfare from ocean activities, and of the legal aspects of resource management; and

(3) Evaluating the total national program in terms of the legislative mandate and reporting annually to the Congress on accomplishments, budgets, and needed legislation.

Role of the Council

The National Council on Marine Resources and Engineering Development was created in the Executive Office of the President to assist the President in planning, development of policy, and coordination of the activities of the 11 Federal departments and agencies with marine science interests (see table A). The Council has also carried out policy-planning functions for the Sea Grant Program, established by Public Law 89–688 and administered by the National Science Foundation. (See app. B–3 for the text of the Sea Grant Act.)

Table A—Federal Marine Science Activities

Agency	Mission
Department of State	Participation in international organizations; sup port of international fisheries commissions international marine policies.
Agency for International Development.	Foreign assistance and food resources for developing nations.
Department of Defense (Navy; Advanced Research Projects Agency; Army Corps of Engineers.)	All phases of oceanography relating to national security; naval technology; statutory civilian responsibilities: Great Lakes, river, harbor, coastal, and ocean charting and forecasting; Great Lakes, river, harbor, and coastal development, restoration, and preservation.
Department of the Interior (Geological Survey; Federal Water Pollution Control Administration; Bureau of Commercial Fisheries; Bureau of Sport Fisheries and Wildlife; Bureau of Mines; Bureau of Land Management; National Park Service; Bureau of Outdoor Recreation; Office of Saline Water; Office of Marine Resources.)	Management, conservation, and development of marine natural resources; lead responsibility for coastal zone management planning and research;[1] measurement and enforcement of water quality standards; acquisition, preservation, and development of coastal areas; identification and development of technology for evaluation of mineral resources; identification of sources and interrelationships for supply of fresh water.
Department of Commerce (Environmental Science Services Administration; Maritime Administration.)	Lead responsibility for air/sea interaction program and marine environmental prediction program;[1] tsunami and hurricane warning; charting and mapping of coastal and deep-ocean waters; research on ship design, shipbuilding, and ship operations; marine transportation and port systems.

Agency	Mission
Department of Health, Education, and Welfare. (Public Health Service; Office of Education; Food and Drug Administration.)	Human health, healthfulness of food, biomedical research, and support of education.
Department of Transportation..... (Coast Guard; Office of the Secretary.)	Safety and protection of life and property in port and at sea; delineation and prediction of ice masses; navigation aids; oceanographic and meteorological observations; transport systems analysis and planning.
Atomic Energy Commission.......	Radioactivity in the marine environment; development of marine nuclear technology.
National Aeronautics and Space Administration.	Feasibility, design, and engineering of spacecraft and sensors for ocean observations.
National Science Foundation......	Basic and academic oceanography; lead responsibility for Arctic research and the International Decade of Ocean Exploration [1]; facilities support; Sea Grant colleges and programs.
Smithsonian Institution...........	Identification, acquisition, classification, and ecology of marine organisms; investigations of the geophysical factors of oceanic environment.
National Council on Marine Resources and Engineering Development.	Assist the President in planning, development of policy and coordination of Federal marine science activities.

[1] Lead agency designation involves Federal leadership for stimulating the exchange of ideas with other interested agencies; planning in terms of the identification of goals with the advice and assistance of other agencies; and negotiating interagency support required for the achievement of goals in these areas—goals to be achieved through multiple, coherent activity of the interested agencies—funding gaps, where possible. No transfer of any agency's statutory responsibilities is involved.

Underlying the Council's activities have been three fundamental concepts:

1. While the Government through its departments and agencies provides much of the leadership and support for ocean research and exploration, the development and exploitation of marine resources is the responsibility of private enterprise.
2. State and local participation are critical to the successful management of activities in the coastal marine environment.
3. In view of the inherently international character of the oceans, a multi-national approach to many uses of the sea is essential.

Annual Reports—A Measure of Progress

In accordance with the provisions of the Marine Sciences Act, the President annually transmits a report to the Congress on the state of the Nation's marine sciences program, describing the activities and accomplishments of the Federal departments and agencies, evaluating these accomplishments, and setting forth recommendations as to future policies, programs, and funding.

The first annual Marine Sciences Council report to the President was prepared in 1967, entitled "Marine Science Affairs—A Year of Transition." The report emphasized the transition from scientific oceanography to application of these scientific discoveries, and the transition from considerations largely at the program level to a new concern and responsibility at the policy level of Government.

The second annual report, entitled "Marine Science Affairs—A Year of Plans and Progress," presented a broad range of policy considerations relating the potential of the oceans to major national goals and to action programs to aid in their achievement. It laid the basis for intensified Government-wide planning efforts and for increased emphasis on selected priority areas such as the war on hunger, international cooperation, and implementation of the Sea Grant Program.

The third annual report, entitled "Marine Science Affairs—A Year of Broadened Participation," summarized accomplishments in 1968, and emphasizing the relationship of marine science affairs to the mainstream of public policy and to non-Federal institutions. New emphasis was directed to the rational development of the coastal zone, Arctic development, and to steps leading to a framework of international law and cooperation in the oceans.

This fourth annual report, "Marine Science Affairs—Selecting Priority Programs," summarizes accomplishments in 1969, describing Federal programs and policies, and new programs implemented to meet those policies. The report describes the priorities that have been selected in the Federal marine science program during 1969. A new level of maturity is reflected in U.S. oceanic activities, the Nation having advanced from the identification of critical issues, to the establishment of priority goals, and the development of urgent programs to meet those goals. A fundamental precept guiding Federal marine science activities during the past year has been that of preserving the quality of the environment. Longstanding national efforts to protect U.S. citizens from natural hazards of the environment have now been joined by the important and essential objective of protecting the environment from man and his technology.

The first chapter of this annual report reviews the steps taken by the Federal Government during 1969 to advance and fund the marine science program toward goals set forth in the Marine Sciences Act, including the Presidential approval of a priority, five-point program for fiscal year 1971 with emphasis on development of plans for coastal zone management, coastal zone research, lake restoration, Arctic research, and U.S. participation in the International Decade of Ocean Exploration.

The second chapter highlights the issue of marine environmental quality and examines the many important factors bearing on degradation of the ocean, including the causes, effects and prevention of pollution, and misuse of the marine environment; the third chapter reports on growing national coastal zone activity and a new Federal policy for the coastal zone—the area most threatened by problems involving marine environmental quality.

The ensuing chapters describe Federal marine science objectives and programs that serve the following public objectives:

1. Facilitating transport and trade.
2. Developing nonliving marine resources.
3. Gaining a greater understanding of the marine environment and an improved ability to predict its processes.
4. Improving national use of ocean data.
5. Strengthening military programs for national security.
6. Accelerating use of food from the sea.
7. Improving the training and education of marine science manpower.
8. Expanding national capabilities to work in the sea.

The two remaining chapters on international policy and the International Decade of Ocean Exploration describe the substantial increase in international oceanic activities, U.S. foreign policy initiatives, United Nations activities relating to the world ocean and seabed, and the decision nationally and internationally to implement an International Decade of Ocean Exploration.

The decision to proceed with the five-point program reveals an important consideration bearing on the broad spectrum of U.S. marine science activities: The more the Nation uses the marine environment, the more knowledge it finds it requires. New problems point to the need for intensified study and wise management of marine resources if the Nation is to extract benefits over the long term.

The appendices provide detailed marine sciences program and budgetary information for fiscal years 1969–71 and include—

(1) Federal legislation and congressional resolutions relating to the marine sciences;

(2) Marine Sciences Council activities, contracts, reports, and testimony;

(3) International marine science activities, including resolutions of the XXIVth U.N. General Assembly, and the draft seabed arms control treaty;

(4) Sea Grants projects and programs; and

(5) Listings of U.S. oceanographic ships and undersea vehicles, and hyperbaric facilities in the United States.

Chapter I

MARINE SCIENCES AND NATIONAL GOALS

In recent years, the United States has recognized the importance and potential that the world ocean holds for the Nation's well-being and security. Internationally, the potential of the oceans has stirred intensified interest.

The world community has come to recognize the ocean as a primary generator of much of the world's weather and the source of nearly all moisture upon which life on the continents depends. Nations which some 25 years ago first turned to the seabed for sources of fuel now realize 16 percent of the free world output of oil and gas from offshore wells. Nations have recognized, too, that the oceans provide a source of protein that may assist in solving the world food problem.

The United States has come to appreciate the esthetic as well as the economic values of its precious natural coastline. Forty-five percent of the Nation's population is concentrated in coastal counties. Future burgeoning megalopoli will further crowd the coast, and intensified use will generate conflict between those who wish to transport bulk cargoes of ore, fuel and chemicals through the Nation's marine gateways, those who wish to develop industry, those who wish to live, swim, fish, and sail along the coast, and those who seek to dump municipal and industrial waste into "convenient" estuarine sinks.

Federal marine science activities in 1969 clearly reflected the Nation's growing use of the world ocean. The Marine Sciences Council continued to assist the President in planning, development of policy, and cordination of Federal programs. During 1969 the Council placed increased emphasis on consideration of management and institutional issues bearing on the Nation's evolving ocean program. The policy and program decisions taken during the year served to indicate the Nation's increased awareness of the need to understand, manage, and make wise and efficient use of the marine environment; an awareness that—

(1) Growing concentrations of population along the coasts of the United States and the world, with attendant problems of multiple use and threats of marine pollution, require immediate, careful attention;

(2) The oceans can be used to help meet the Nation's and the world community's economic and social needs;

Surf pounds Sunset Cliffs, San Diego, part of the Nation's 17,000-mile coastline. During 1969, increased Federal attention was devoted to coastal zone policy and programs.

(3) New knowledge and evolving technology will speed greater, more rational realization of the ocean's benefits; and

(4) The oceans will continue to play a major role in national defense.

In 1969, Federal programs in marine science, technology and related activities continued to develop, and in fiscal year 1971 the marine sciences budget will increase by approximately $19 million to a total of $533 million. The President approved a priority, five-point program to strengthen the Nation's marine science activities in fiscal year 1971. In support of the President and in keeping with its legislative manmade, the Marine Sciences Council examined ocean issues of national importance at a Government-wide policy level and developed recommendations for Presidential consideration.

In 1969, major policy and program decisions, marine research findings, ocean engineering developments, and achievements of ocean industry supported the objectives of the Marine Sciences Act. Emphasis, in particular, was placed on preservation of marine environmental quality and on rational management of the Nation's coastal zone. Further study of lake restoration, to determine the feasibility of restoring the quality of some of the Nation's seriously damaged waters, was announced. The development of Federal policies for coastal zone management and coastal zone research was undertaken, and new programs of Arctic research and international cooperative exploration were planned—each serving to advance the United States as a leader in marine science and resource development.

Major research programs such as the Barbados Oceanographic and Meteorological Experiment (BOMEX) and the ocean sediment coring program contributed to the expansion of human knowledge of the marine environment. The cooperative Government/industry Tektite I experiment contributed to the development of man-in-the-sea capabilities. The Gulf Stream drift mission of the submersible *Ben Franklin,* the Arctic voyage of the supertanker SS *Manhattan,* and the launching of the Navy's nuclear powered research and engineering submersible, NR–1, illustrated national advances in marine engineering and technology. Bilateral and multilateral seabed arms-limitation discussions and the international decision to proceed with the International Decade of Ocean Exploration as part of an expanded program of ocean exploration and research were indicative of progress toward peaceful, cooperative use of the world ocean.

Federal Marine Sciences Policy

During 1969, the administration gave careful consideration to marine science problems and objectives in the context of overall national needs and priorities. Immediately after entering office, the President asked the Vice President and Council members for recommendations on the proposals made by the Commission on Marine Science, Engineering and Resources.

On January 9, 1969, the Commission had presented its report, "Our Nation and the Sea," [1] to the President and the Congress. The Commission had been established under provisions of Public Law 89–454, to "make a comprehensive investigation and study of all aspects of marine science in order to recommend an overall plan for an adequate national oceanographic program that will meet the present and future national needs." The Commission's report contained a total of 122 recommendations in the areas of marine science, marine technology, manpower development, scientific and technical information, coastal management, coastal development, pollution control, living resources, mineral resources, Government-industry relations, research and exploration, global monitoring and prediction, environmental modification, technical and operating services, and organization for the national ocean program.

The Marine Sciences Act assigned responsibility to the Marine Sciences Commission to recommend an overall, long-range plan for the national ocean program, including a recommended governmental organizational plan for the national program. Among the Commission's broad-ranging recommendations was the call for Federal Government reorganization in the marine sciences bringing together many of the organizationally separated Federal agencies in a new civilian agency, the National Oceanic and Atmospheric Agency (NOAA), which was proposed to serve as the principal instrumentality within the Federal Government for administration of the Nation's civil marine and atmospheric programs.

Following review of the Commission's recommendations by the Federal agencies, the President asked the Chairman of his Advisory Council on Executive Organization to evaluate the proposal for a NOAA in the context of a broader review of Federal organization, taking into account related environmental and natural resource areas.

The organizational views of the Federal agencies are under review. The President's Advisory Council on Executive Organization is scheduled to report its recommendations on organization of Federal environmental, natural resource and oceanographic programs to the President by April 15, 1970.

Following careful governmental review of the report, the Vice President recommended that Federal agencies take the Commission's program recommendations into account when developing their fiscal year 1971 and future programs and priorities.

In May, 1969, the President requested the Marine Sciences Council to encourage further improvements in the coordination of Federal marine

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[1] "Our Nation and the Sea," report of the Commission on Marine Science, Engineering and Resources, U.S. Government Printing Office, January 1969; and Panel Reports of the Commission, available as a set from the U.S. Government Printing Office: Vol. 1: Reports of Panels on Basic Science, Environmental Monitoring, Management and Development of the Coastal Zone, and Manpower, Engineering and Training; Vol. 2: Reports of the Panels on Industry and Private Investment and Marine Engineering and Technology; and Vol. 3: Reports of the International Panel and the Panel on Marine Resources. In keeping with the provisions of the Marine Resources and Engineering Development Act, the Commission ceased to exist 30 days after the submission of its report.

science activities. To carry out the Council's responsibilities, the Vice President took steps to augment the Council's policy advisory mechanism by establishing the Committee for Policy Review staffed by officials from the member agencies of the Council at the Assistant Secretary level, and chaired by the Council's Executive Secretary. (The Council's committees are outlined in table I–1.)

Table I–1—Committees of the Marine Sciences Council

[The committees of the Council have the general responsibility for advising and assisting the Vice President and the Council, analyzing current and future activities of the Federal agencies, and undertaking studies and submitting recommendations to the Council, either as assigned or on their own initiative. During 1969, the Council's operating procedures were augmented with the establishment of the Committee for Policy Review and the dissolution of the following committees: Committee on Marine Research, Education, and Facilities; Committee on Ocean Exploration and Environmental Services; Committee on Food from the Sea; and Committee on Multiple Use of the Coastal Zone.]

Committee	Responsibility	Chairman
Committee for Policy Review.	National policy pertaining to the marine environment; review and evaluation of marine science issues requiring interagency attention by the Government at the policy level; development of analyses and recommendations for consideration of such issues by the Council. The Committee establishes interagency task forces and subsidiary bodies, as required, to develop specific issues and recommendations for its consideration.	Edward Wenk, Jr., Executive Secretary, National Council on Marine Resources and Engineering Development.
Committee on International Policy in the Marine Environment.[1]	U.S. foreign policy pertaining to the marine environment; international activities and initiatives pertaining to the marine environment, including cooperation by the United States with other nations and participation in international organizations and meetings.	U. Alexis Johnson, Under Secretary of State for Political Affairs.

[1] Established by the Secretary of State, at the request of the Vice President, to serve the mutual interests of the Council and the Department of State.

The Committee for Policy Review has met eight times since its establishment in June 1969, and has—

(1) Endorsed establishment of an *ad hoc* planning staff under the Council secretariat to develop a detailed program for the International Decade of Ocean Exploration, and subsequently, reviewed and endorsed the Decade plan prepared by the planning staff;

(2) Established other *ad hoc* task forces to deal with significant and urgent issues, such as coastal zone management; marine laboratories; national technology projects; man-in-the-sea; and ship utilization—and acted on their recommendations;

(3) Recommended assignment of lead agency responsibility for marine environmental prediction to the Department of Commerce, and approved the Department of Commerce's plan for implementing the marine environmental prediction program;

(4) Recommended assignment of lead agency responsibility to the Department of the Interior for coastal zone management and requested the Department of the Interior to develop plans for coastal zone research;

(5) Took action on recommendations made by a Review Panel composed of non-Federal experts which included an agency review of major marine research programs, priorities for advanced ship research, ports and harbors, food-from-the-sea programs, and an Office of Naval Research review of submersible utilization;

(6) Requested and endorsed Sea Grant policy developed by the National Science Foundation and its Office of Sea Grant Programs; and

(7) Recommended a strengthened and broadened role for the National Oceanographic Data Center and its Advisory Board.

The Five-Point Program for Fiscal Year 1971

In October 1969, the President approved a priority marine science program for fiscal year 1971 with emphasis on the following five areas:

1. *Coastal zone management.*—A new policy will encourage States to improve their management of coastal areas and the Great Lakes, with a grant program to aid States to plan and manage coastal activities. To this end, the Department of the Interior, on behalf of the administration, submitted a legislative proposal to the Congress providing for the establishment of a national policy for the development of coastal areas and authorization of Federal grants, with matching State contributions, to encourage and facilitate the establishment of State planning and regulatory mechanisms. Such legislation should assist in insuring that rapid coastal development does not destroy limited coastal land and water resources and that all interests in the coastal regions would be assured consideration—for port development, navigation, commercial fishing, mineral exploitation, recreation, conservation, industrial development, housing, and power generation.

2. *Coastal zone research.*—Steps will be taken to identify requirements for research and analysis related to coastal zone problems, to assess the adequacy of existing Federal, State, and other institutions to provide required research, and to determine how additional research can be used to improve the management of coastal zones.

3. *Lake restoration.*—To determine the feasibility of restoring the quality of some of the Nation's seriously damaged waters, including the Great Lakes, lesser lakes and many estuaries, by testing existing clean-up technology on smaller bodies of water, and developing new methods to establish the most practical and economical means, studies will be initiated. The Department of the Interior is assigned the responsibility for the lake restoration program, and work is already proceeding under the auspices of the Federal Water Pollution Control Administration for research on some portions of the problem.

4. *International Decade of Ocean Exploration.*—Funding will be provided for U.S. programs which will be a part of the International Decade of Ocean Exploration, and the United States will propose international

emphasis on the following goals: Preserving the quality of the ocean environment, improving environmental forecasting, expanding seabed assessment activities, developing an ocean monitoring system to facilitate prediction of oceanographic and atmospheric conditions, and improving worldwide data exchange. It is hoped that accelerated Decade planning will increase opportunities for international sharing of responsibilities and costs for ocean exploration, and will assure better use of limited exploration resources.

5. *Arctic environmental research.*—Arctic research activities will be intensified, both to permit fuller utilization of this rapidly developing area and to insure that such activities do not degrade the Arctic environment.

Funding for the implementation of these programs is provided in the President's fiscal year 1971 budget. The programs are clearly related to national goals and require priority attention. They reflect the appropriate role of the Federal Government in providing information about the environment and in protecting the public interest, as for example with coastal resources that are held in trust for U.S. citizens by the individual States. They note the transition from the time when man had to protect himself from a harsh environment to a new era when he must protect the environment from himself. They reflect a strong desire for other nations to join in the exploration of the sea and to share in the cost of exploration as well as in the benefits.

The Federal Marine Sciences Budget

Increases in the Federal marine sciences budget reflect the policy decisions taken with the five-point program. Obligations for marine science, technology, and related activities in civilian agencies will increase by $42 million in fiscal year 1971 over fiscal year 1970 and $74 million over fiscal year 1968, as indicated in table I–2. The increase for civilian programs is partially offset by reductions in Navy mapping and charting and deep submergence programs.

A major trend in the new and expanded programs in civilian agencies involves observing, measuring, and understanding conditions and trends in the marine environment and man's impact upon it; this trend is reflected in table I–3 which presents the Federal marine sciences program by major purpose. Increases are provided in the National Science Foundation for the International Decade of Ocean Exploration, for expanding the ocean sediment coring program, for Arctic research, and for the national Sea Grant Program—particularly to support coastal zone research. Funds are requested for the Department of the Interior for the new coastal zone management grant program and for the initiation of a lake restoration program. Increases in the Department of Transportation will permit expansion of advanced development of ocean data buoys for monitoring weather and sea conditions. In the Department of Commerce, increases are provided in the Maritime Administration for beginning a long-term program for reducing ship operating costs—a part of the administration's maritime program.

Within the Department of Defense, the Advanced Research Projects Agency will begin work on surface effects vehicles. However, this increase in defense is more than offset by reductions in other areas.

Developing a Concerted National Effort

An overview of the Nation's marine science program highlights the wide range and diversity of purposes, institutions, specialized bodies of knowledge, and Federal activities that make up the missions of 11 departments and agencies. Two administrations since enactment of Public Law 89–454 have employed the Marine Sciences Council to assist the President in marine science policy development, planning and coordination so as to develop a concerted national effort. Underlying the Council's method of operating are three concepts—

(1) It should aid in strengthening the programs of the agencies and in coordinating activities so as to foster an enterprise stronger than the sum of its parts;

(2) Its scope of activity, in keeping with the spirit of the legislation to take into full account all the uses of the oceans, should be broader than programs of scientific oceanography; and

(3) Emphasis should be placed on the institutional framework and governmental processes by which science is blended with considerations of law, socioeconomics, and public policy and should seek new ideas within and outside Government.

The Council has assisted two administrations to (*a*) identify unmet needs and opportunities to which Federal marine science programs could be directed, especially gaps in programs that cross agency lines; (*b*) recommend priorities on a Government-wide basis by selecting areas deserving additional emphasis; (*c*) identify impediments to progress and strategies for their circumvention; (*d*) develop policies by which the objectives and programs of one agency will not inadvertently conflict with equally valid but independent activities of another; (*e*) recommend—in those cases where missions of several agencies may overlap—that one agency assume a lead responsibility for Government-wide planning, guiding, coordinating, and assuring fiscal support; (*f*) coordinate—through a committee structure—programs which are of concern to many agencies; (*g*) insure that the appropriate sources of the Federal Government are brought to bear on mutually agreed upon goals; (*h*) evaluate programs so as to eliminate marginal activities; and (*i*) develop background, legal, economic, and technological studies for identifying alternative policies and criteria for choice.

The Marine Sciences Council's professional staff includes specialists in ocean sciences, engineering, national security affairs, public administration, data, marine geology, economics, and international relations. The Council staff assists in identifying policy issues, developing and analyzing background material, and proposing action programs. Also, the Council obtains additional advice through contract studies and from its consultants.

In addition to developing recommendations for the President, the Council, through its secretariat, has—

(1) Prepared an annual report for the President—a comprehensive description of the marine science activities, funding, and accomplishments of all agencies and departments of the U.S. Government;

(2) Sponsored legal and long-range policy studies, directed toward developing background for Presidential policy development and program coordination;

(3) Released to the public a compilation of 2,600 marine science projects sponsored by the Government, oceanographic ship operating schedules, potential of spacecraft oceanography, and documentation on marine science activities of some 100 countries; [1]

(4) Brought the views of State and local governments, universities and industries, more directly into the main stream of national policy planning; and

(5) Responded to congressional requests for testimony and commentary for several congressional committees on legislation dealing with marine affairs.[2]

Table I-2—Total Federal Program [1] by Department and Independent Agency

[In millions of dollars]

	Estimated fiscal year 1969	Estimated fiscal year 1970	President's budget, fiscal year 1971
Department of Defense [2] [3]	259. 7	263. 8	239. 7
Department of the Interior [4]	80. 8	98. 5	95. 0
National Science Foundation	34. 9	40. 7	63. 0
Department of Commerce	38. 1	49. 2	58. 9
Department of Transportation	19. 8	31. 3	[5] 42. 6
Atomic Energy Commission	10. 6	10. 0	9. 7
Department of Health, Education, and Welfare	7. 3	7. 0	9. 0
Department of State	6. 9	7. 7	8. 4
Agency for International Development	1. 5	2. 6	2. 6
Smithsonian Institution	1. 9	1. 9	2. 4
National Aeronautics and Space Administration	1. 9	1. 8	1. 8
Total	463. 4	514. 5	533. 1

[1] Many programs of the Departments of Defense, Commerce, Interior and Transportation, and other agencies closely related to marine sciences, are not included.
[2] Totals include for the first time ARPA's advanced surface platforms program ($1.9, $6, and $12.3 million for the respective years).
[3] Excludes development of the Navy's surface effects ships program ($3.3, $7.9 and $20 million in the respective years).
[4] Totals include for the first time marine research supported by the Office of Water Resources Research ($0.5, $0.9, and $1.1 million for the respective years).
[5] Does not include new $59 million replacement icebreaker which has oceanographic research capabilities.

NOTE: The totals for FY 70 and 71 differ slightly from those published at the time the President's Budget was released in February due to subsequent Department of the Navy re-allocations which affected the Navy's budget for designated marine science efforts.

[1] See app. C–3.
[2] See app. C–1.

Table I-3—Total Federal Marine Science Program [1] by Major Purpose

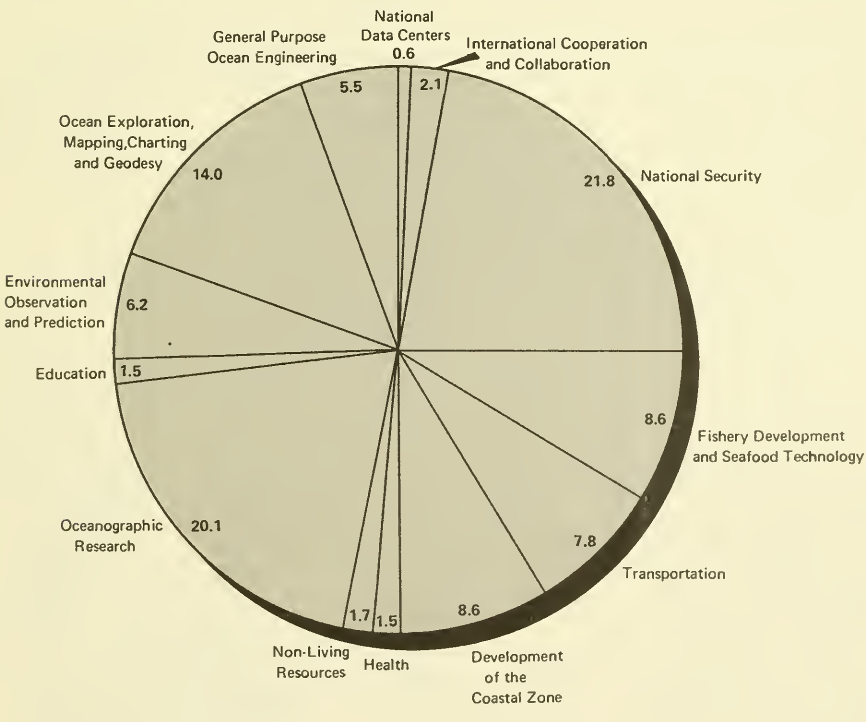
[In millions of dollars]

Activity and supporting agency	Estimated fiscal year 1969	Estimated fiscal year 1970	President's budget fiscal year 1971
International cooperation and collaboration	8.4	10.3	11.0
National security	127.2	129.1	116.1
Fishery development and seafood technology	45.3	52.2	45.6
Transportation	16.7	29.6	40.9
Development of the coastal zone	32.1	40.7	45.8
Health	6.0	5.9	8.2
Nonliving resources	8.0	9.2	9.2
Oceanographic research [2]	78.4	82.5	108.2
Education	6.7	8.4	8.2
Environmental observation and prediction	33.7	31.7	32.8
Ocean exploration, mapping, charting, and geodesy	79.7	89.4	74.7
General purpose ocean engineering	19.1	22.8	29.5
National data centers	2.2	2.7	3.0
Total	463.5	514.5	533.1

[1] Many programs of the Departments of Defense, Commerce, Interior, and Transportation, and other agencies closely related to marine science, are not included. Programs supported by ARPA on advanced surface platforms and by Interior's Office of Water Resources Research on marine research are included for the first time.

[2] Research beneficial to more than one of the other major purpose categories.

Figure I-1—The Marine Science and Technology Dollar, Fiscal Year 1971



Chapter II

PERSPECTIVE ON PRESERVING THE MARINE ENVIRONMENT

The earth is a water planet. The global ocean's 140 million square miles of surface and 330 million cubic miles of water stretch over 70.8 percent of the earth's surface and wash the shores of over 100 nations. The waters of the ocean have a profound influence on man and his environment. They play a major role in governing his climate. Their phytoplankton produce over half of the earth's oxygen. They are a rich source of food, energy, and minerals, a highway of commerce, a receptacle for wastes. The ocean's shores are the site for urban centers and industry, a place of refuge from industrial civilization for the commercial and sports fisherman, swimmer, boatsman, and sunbather.

Man is only one of the ocean's users, and the most recent. The ocean, likely the original source of life, is populated by a pyramid of living creatures whose abundance, variety, antiquity, peculiarity, beauty, and balance are among nature's wonders. Life is found throughout the ocean's waters, but most living creatures of the sea inhabit the coastal zone and the shallow continental shelf areas. Here land and water meet and the nutrients mingle. The estuaries, lagoons, wetlands, and beaches are primary sanctuaries for water fowl, nurseries for coastal fisheries, habitats of a rich variety of plants and animals. It is estimated that most of the total domestic U.S. commercial fish catch is obtained from the Nation's coastal zone.

Upsetting the Ocean's Ecological Balance

The history of life in the ocean is one of interaction between the living creatures and the oceanic environment—the water, the air, and the land. To a large extent the shapes and habits of each living creature in the sea have been molded by that environment. Each has adjusted to and has been shaped by the ocean, and over the millions of years a series of delicately adjusted, interlocking relationships have developed. The life of all parts of the ocean is linked—the plankton to herring and mackerel, to tuna and shark, to squid and whale. These links also extend to the land and man.

Today, in many places, the ocean's ecological balance is endangered. Man has acquired and employed the means, deliberate or accidental, to alter the ocean environment, and measured in the time of evolutionary change the living creatures in that environment do not have the time to adjust. Contamination of the ocean has begun. Chemical wastes from fac-

Pollution has forced the city of Cleveland to fence and chlorinate a section of Lake Erie to provide city residents with a place to swim.

tories, heat from powerplants, domestic wastes and sewage from cities and towns, insecticides and fertilizers from land runoff, atmospheric fallout of gasoline vapors, low level radioactive wastes from reactors, laboratories, and hospitals are all flowing into the ocean. The sheer bulk of the material disposed of and the presence of new types of nondegradable waste products are now beginning to affect the ocean at an increasing rate; the wastes can no longer so readily be diluted, dispersed, or degraded.

Dumpings and discharges into the water are only part of the problem. Physical changes in the coastal environment result from erosion due to wind, waves, tides, storms, and man's uses and misuses of coastal lands. Erosion introduces pollutants into the water; the material moved and deposited clogs navigation channels and suffocates marine life. Modifications of submarine areas by dredging and mining disturbs the habitat of marine and marsh life. Upstream dams and river diversions permit saline water intrusions from ocean to estuary to the detriment of marine life.

As a consequence of these actions and activities, ocean pollution—once of little concern because the ocean was considered so large as to be unlimited in its capacity to absorb wastes—is recognized as a growing problem. We have found today, as we found earlier with our rivers and lakes, that every body of water, including the ocean, has limited capacity to absorb and neutralize inflowing materials.

Pressures are mounting which will aggravate these problems. The world's rapidly growing population is clustering near the coastlines. In the United States, 75 percent of our population inhabits States bordering on a 17,000-mile shore; 45 percent of our population lives in coastal communities, and coastal urban development is mounting. By the year 2000, the U.S. population will increase by about 60 percent and most of our major megalopoli will crowd the Nation's coastal zone. Other areas of the world face similar pressures of man and his technology on the environment—of the world's 10 largest metropolitan areas, seven lie on major oceanic estuaries.

The growth of population and its migration to the shore have led to expanded activities on and uses of the sea, worsening the pollution problem. A preponderance of the Nation's heavy industrial investment is located along the coast. It is estimated that, despite abatement efforts, industrial pollution of the ocean alone is growing at a rate of 4.5 percent annually—three times faster than the growth of population. New uses of the coastal zone are foreseen—offshore airports, oil terminals, nuclear power generation plants and trunk sewers. The 16,000-ton tanker of 25 years ago has given way to today's 300,000-ton supertanker, with the potential for massive oil spills resulting from accidental breakups. With more ships on the sealanes, more accidents are likely. With more offshore oil drilling, the threat of well blowouts increases. Some 16,000 oil wells have already been drilled off U.S. coasts, and the number is augmented by 1,000 each year. The President's Panel on the Santa Barbara, Calif., oil spill concluded we may expect an average of one major oil spill each year after 1980.

In 1969 a number of serious incidents signaled future dangers of ocean pollution. The Santa Barbara oil spill, described in chapter III, destroyed waterfowl and property. The Food and Drug Administration was forced to condemn some 700,000 coho salmon caught in Lake Michigan because they

contained unacceptable concentrations of DDT. The Heyerdahl expedition drifting in midocean between Africa and South America encountered numerous large patches of putrid water, and reported the ocean was "visibly polluted by human activity." The voyage of the tanker *Manhattan* to the Arctic suggested the need to prepare for possible oil spills in polar regions. Scientists investigating the "Crown of Thorns" starfish whose explosive growth has led to the destruction of Pacific Ocean corals attribute the growth in part to man-induced pollutants and the physical modifications resulting from dredging and blasting which reduced the starfishes natural enemies.

Characteristics of Ocean Pollution

Pollution of the ocean has several pronounced characteristics. First, it is long lasting. Rivers renew themselves each year and carry pollutants from their course, and lakes can cleanse themselves over decades or centuries. But the ocean is the final depository of pollutants which will remain there for thousands of years. This is particularly true of materials which do not dissolve or readily break down in water. Lead from gasoline exhaust entering the oceans today will be circulating or deposited on the sea floor centuries from now.

Some pollutants in the sea may accumulate in the ocean's food chain where they build up in the marine life cycle. Entering the food chain in marsh water from agriculture runoff, DDT travels through the food chain and accumulates in fish-eating birds in often injurious concentrations. It has interfered with the reproductive cycle of the osprey and peregrine falcon and has been found in large quantities in Antarctic skua, Atlantic and Pacific shearwaters and Bermuda petrels.

The global ocean is a great circulating system in constant horizontal and vertical motion. Pollutants entering the system may travel long distances over the earth's surface. Pesticides used on the African Continent have been found in the Bay of Bengal and the Caribbean Sea after traveling in the monsoon and the northeast trade winds. Some of the pesticides found in the Great Lake coho salmon appear to have originated far inland. Acetone and butyaldehyde, harmful to life, have been detected in surface waters of the Florida straits, the Mediterranean Sea, and the Amazon estuary.

Nor is ocean pollution any respector of political boundaries. Like the ocean environment, it reaches the shores of many States and nations. Air and ocean pollutants travel long distances and can menace the ecological balance and environmental quality of nations far from the source.

Sources of Pollutants

Pollutants enter the ocean from many sources. The quantity of municipal, industrial, and agricultural waste deposited in the ocean is enormous. With urbanization, oceanic waste disposal is increasing, particularly affecting the quality of water near population concentrations and in estuaries.

Municipal sewage includes almost everything that goes down the sewer system from homes and streets. Agricultural wastes include salt from erosion, fertilizers, pesticides and runoff from feedlots. Industrial wastes consist of acids, chemicals, and animal and vegetable matter produced by paper, steel, meat processing, and other industries. Dredging spoils, sand, refuse, waste oil, industrial chemicals, and sludges are transported by tug and barge and dumped into the ocean. Industrial chemicals released in the atmosphere or dumped into rivers find their way to the ocean. Drycleaning solvents are evaporated into the atmosphere at a rate of 350,000 tons per year. In the United States 1 million tons of gasoline yearly is lost through evaporation, much of which is eventually deposited in the ocean.

Specific oceanic disposal areas are defined off New York Harbor for sewage, sludge, mud, and stone, cellar dirt and waste acid; off Delaware Bay for sewage sludge; off Boston and Charleston Harbors for dredged material. The overall affect of such large-scale disposal on the marine environment will require careful study.

Because of its highly industrialized society, the United States is believed to be responsible for approximately one-fifth of the world's coastal effluents. Estimates indicate that 48 million tons of solid wastes were disposed at sea off U.S. coasts in 1968 at a cost estimated at $29 million. These estimated amounts and costs are set forth in table II–1.

The ocean is increasingly being used as a disposal site for wastes, yet the effects on the marine environment are little known. Depicted is 1 ton of mechanically compressed garbage which was dumped into the ocean as part of an experiment investigating new methods of waste disposal.

Table II–1—Estimated Amounts and Costs of Wastes Barged to Sea in 1968 [1]

Wastes	Pacific coast disposal		Atlantic coast disposal		Gulf coast disposal	
	Tons	Cost	Tons	Cost	Tons	Cost
Dredging spoils	7,320,000	$3,175,000	[2] 15,808,000	$8,608,000	15,300,000	$3,800,000
Industrial wastes (chemicals, acids, caustics, cleaners, sludges, waste liquors, oily wastes, etc.):						
Bulk	981,000	991,000	3,011,000	5,406,000	690,000	1,592,000
Containerized	300	16,000	2,200	17,000	6,000	171,000
Garbage and trash [3]	26,000	392,000				
Miscellaneous (airplane parts, spoiled food, confiscated material, etc.)	200	3,000				
Sewage sludge			[4] 4,477,000	4,433,000		
Construction and demolition debris			574,000	430,000		
Totals	8,327,500	4,577,000	23,872,200	18,894,000	15,996,000	5,563,000

[1] Does not include outdated munitions.
[2] Includes 200,000 tons of fly ash.
[3] At San Diego dumping of 4,700 tons of vessel garbage at $280,000 per year was discontinued in Nov. 1968.
[4] Tonnage on wet basis. Assuming average 4.5 percent dry solids, this amounts to approximately 200,000 tons dry solids per year being barged to sea.

Source: Marine Disposal of Solid Wastes, an Interim Summary, Oct. 1969. Dillingham Corporation, Applied Oceanography Division Under Contract to Bureau of Solid Wastes Management, Department of Health, Education, and Welfare, October 1968.

Oil pollution is an increasing threat to the marine environment. The world's annual oil production of 1,800 million metric tons, is increasing 4 percent each year. Some 60 percent (or 1,000 million metric tons) is transported by sea, much of it in restricted shipping lanes. Estimates indicate that 0.1 percent of the total transported, or about 1 million tons per year, is spilled or leaked into the marine environment.

More dramatic and destructive in the short term are massive oil spills such as the *Torrey Canyon* tanker disaster and the drilling mishap at Santa Barbara. The harmful effects of the spills, and in the case of the *Torrey Canyon* the destruction from use of detergents to clean up the oil, were serious for property and marine life. High mortality of waterfowl and marine life, accumulation of hydrocarbons in the food chain of surviving fish, and overall damage to marine life and property were observable consequences.

Burned fossil fuels, of which the United States is responsible for over one-third of the world's total, go in part to the seas as residues containing carbon dioxide, sulphates, and nitrates. Estimates indicate the carbon dioxide level of ocean surface waters has increased markedly since the beginning of the industrial revolution. Solid smoke particles accumulating in ocean sediments may alter the chemical composition of the ocean.

Two heavy metals, lead and mercury, enter the ocean in part through man-made discharge. Estimates indicate that about 10,000 tons of lead are introduced yearly. Lead concentrations in the Pacific surface waters have

jumped tenfold since tetraethyl lead was first used in gasoline 45 years ago. While some 4,000 to 5,000 tons of mercury are estimated to enter the oceans annually by natural erosion, man introduces an equivalent amount. The element accumulates in fish and plants.

One of the most abundant of the manmade pollutants in the sea is DDT, which is transported in the form of agricultural run off. Like many other manmade substances DDT does not degrade readily in water; nature's natural decomposing forces cannot break it down. Some scientists believe that two-thirds of the 1.5 million tons of DDT produced by man may still be adrift. Moreover, DDT concentrates in the food chain and today is found in all oceans and all marine organisms as well as man.

Other forms of environmental degradation result from man's activities. Physical modifications, such as dredging and filling, construction of dams, diversions, jetties, groins, hurricane barriers and heavy waste disposal, alter natural processes and cause pollution. Heating of coastal waters by industry decreases the oxygen carrying capacity of water, adversely affecting marine life. Seabirds catch their necks in plastic soft drink holders; plastic bags clog water intakes; lost synthetic fishing nets which do not sink or disintegrate continue to catch and destroy fish for years.

Effects of Ocean Pollution

The current effects of marine pollution are harbingers of the serious problems which lie ahead if it is not curbed. Domestic sewage disposal has already spoiled large areas of U.S. shoreline, sections of Lake Erie's accessible shoreline are now off limits to swimmers and fishermen; many estuarine areas in other parts of the country face similar restrictions.

The long-range consequences of pollution are visible in the Great Lakes, especially Lake Erie. The lake is suffocating to death as a result of manmade pollution over the past 50 years. By dumping detergent phosphates, fertilizer nitrates and other pollutants into the lakes, an enormous growth of algae has been generated consuming the oxygen and choking off other life in the process. In five decades the lake has aged the normal equivalent of 15,000 years. Though the cause is not completely known, similar conditions are found today in the shallow Baltic Sea where the dissolved oxygen has decreased in lower depths and dissolved phosphorus has increased.

The hazards to animal life are severe. The shellfish in an estimated 1.2 million acres, or 8 percent, of the Nation's shellfish grounds have been declared unsafe for human consumption. Fish kills in the United States resulting from identifiable pollution sources, principally in fresh water and estuarine areas, are mounting. In 1968 alone, an estimated 15 million fish were killed by pollutants, 31 percent more than the previous year. Municipal sewers and treatment plants, industrial waste and transportation accidents were the main causes. In 1969, a chemical spill in the Rhine River killed an estimated 40 million fish.

The long-range consequence of many pollutants is not clear. The effect of the ocean's increased lead content upon marine life is unknown, as is the long-range impact of the accumulation of solid smoke particles in ocean

Serious beach erosion and wall damage such as this shown at Cliff Walk, Newport, R.I. point to the need for a planned approach to shoreline development. By investigating and determining suitable methods for protecting, restoring and developing the shoreline against wave and current erosion, the recreational and esthetic features of our coasts can be preserved.

sediments. New chemical substances are created at the rate of 400 to 500 annually. Many of them are toxic and will find their way to the ocean; yet full knowledge of their biological effects is lacking and removal methods for them are poorly developed. At the present state of research it is not possible to predict reliably the effects of a given dose of solid waste on the marine environment. Man is still largely ignorant of the long-term and low-level effects of chronic crude oil pollution, such as that released from tankers flushing storage tanks at sea. These effects may be serious and longer lasting. Their dangers are likely to become more critical as transportation of oil, its products and synthetics increases and as petroleum production shifts increasingly to Continental Shelf sources.

Physical modifications of the shoreline, while they may be beneficial to man in numerous ways, can also be harmful. They alter the natural environment and sometimes speed up or slow down the effects of erosion. Dredging unsettles bottom sediments, removes bottom dwelling marine life, reduces the water's ability to assimilate oxygen-demanding wastes, blankets fish nests and masks out light required by aquatic plants. The spoils of dredging dumped as land fill increase water turbidity, smother bottom organisms and alter depths, changing the marine habitat. Dam construction creates barriers to upstream breeding migrations of marine

fish, alters water salinity, affecting marine life such as crabs, shrimp, and oysters. Jetty and groin construction alters the local movement of sand, changing beach ecology and upsetting sessile organisms. Hurricane barriers disturb the normal circulation of bay waters important to aquatic life.

Yet, not all modifications or pollutants are harmful. The heating of coastal waters by the electric power industry provides an example. Under certain circumstances the increased temperature may enrich the productivity of an area by accelerating growth and provide a valuable asset in commercial production of crabs, shrimp, and fish. It may also enhance an area's recreation potential. Aquaculture can be improved through fertilization, and greater yields can be achieved in some cases by fertilizing ponds with biologically purified sewage effluent. Chemical wastes can settle turbidity and clarify water. Car bodies, tires, and rubble have been tested for use as artificial marine habitats for sport fish, and certain acid wastes reportedly have attracted sportfish. Coastal works can help preserve the environment from degradation. More study of the possible beneficial uses of controlled pollution and modifications is needed.

International and National Concern

The dangers of environmental pollution have generated international and domestic concern. Strong public pressures are now building up to determine the nature and extent of these problems and to find solutions to them. Recently the United Nations General Assembly adopted a number of resolutions calling for investigation of the problems and the need to reduce marine pollution.[1]

The Intergovernmental Maritime Consultative Organization (IMCO), the Food and Agriculture Organization (FAO), the World Meteorological Organization (WMO), and the United Nations Educational, Scientific and Cultural Organization (UNESCO) have established a joint Group of Experts on the Scientific Aspects of Marine Pollution.[2] In November 1969, the IMCO assembly decided to convene an international conference to consider adopting a convention on questions relating to marine pollution from oil. The Intergovernmental Oceanographic Commission's Comprehensive Outline of the Scope of the Long-term and Expanded Program of Oceanic Exploration and Research provides for scientific studies on ocean pollution.[3] NATO nations recently acted to enhance their work in the field of the human environment and have urged that this area become one of broader East-West cooperation.

Related international activities promise to increase in the future. The FAO plans to hold a conference in 1970 on marine pollution and its effects on living resources and fishing. The Council of Europe has scheduled a conference on Man and Environment in Strasbourg, France, this year. The Economic Commission for Europe is preparing for a Conference on

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[1] Recent resolutions of the U.N. General Assembly on ocean pollution are included in app. D–1.

[2] Additional actions of the U.N. family of organizations concerning ocean pollution are discussed in ch. XIII.

[3] The expanded program is discussed in greater detail in ch. XIII and XIV.

Problems Relating to the Environment in 1971. The U.N. General Assembly plans to convene in Sweden in 1972 a U.N. Conference on The Problems of the Human Environment, which will include issues related to marine pollution. IMCO plans an international conference to consider reducing ship contamination in 1973.

In the United States recently, concern about the environment and marine pollution has heightened. It has been reflected not only in increased public discussion but also in governmental initiatives and new legislative proposals. Some of the major milestones of U.S. legislation creating policy and regulatory authority for preservation of the marine environment are listed in table II–2. At the Federal level a large number of agencies have important responsibilities for coastal development through such varied functions as water quality planning and enforcement; waste management; control of beach erosion; improvement of ports, harbors and waterways; conservation; provision of nautical charts and sea and storm prediction; acquisition and development of recreational lands and waters; enforcement of maritime safety; shellfish culture sanitation; assisting commercial and sport fishing; and development of scientific understanding of the coastal ecology. Major Federal agencies active in the field and their programs are described in chapter III.

Table II–2—Selected U.S. Milestones in Preserving the Marine Environment

Year	Legislation and governmental initiatives
1899.	*River and Harbor Act.* Prohibited (1) discharge or deposit of refuse into any navigable waters, except that which flowed from streets and sewers in a liquid state; (2) excavation or filling in navigable waters; (3) construction of piers, dams, bridges, and similar works in harbors and navigable waters without permit from the Secretary of the Army acting through the Chief of Engineers.
1912.	*Public Health Service Act.* Authorized surveys and studies of water pollution, particularly as it affected human health.
1924.	*Oil Pollution Act.* Prohibited oil discharges, damaging to aquatic life, harbors and docks and recreation, into the territorial sea and navigable inland waters.
1930.	*River and Harbor Act.* Authorized the Chief of Engineers under the direction of the Secretary of the Army to make investigations and cooperative studies with States for the purpose of preventing erosion of coastal and Great Lakes shores by waves and currents.
1945.	*Executive Order 9634.* Provides for establishing fishery conservation zones in areas of the high seas contiguous to the coasts of the United States and allows for establishing marine wildlife sanctuaries as a fishery conservation measure.
1948.	*First Federal Water Pollution Control Act* with a 5-year expiration date.
1953.	*Federal Water Pollution Control Act* extended for 3 years.
	Outer Continental Shelf Lands Act. Extended the Secretary of the Army's jurisdiction concerning obstructions in navigable waters to include artificial islands and fixed structures located on the Outer Continental Shelf; authorizes the Secretary of the Interior to require the prevention of pollution in offshore oil or mining operations; the Coast Guard administers the act's safety provisions.

Table II–2—Selected U. S. Milestones in Preserving the Marine Environment—Continued

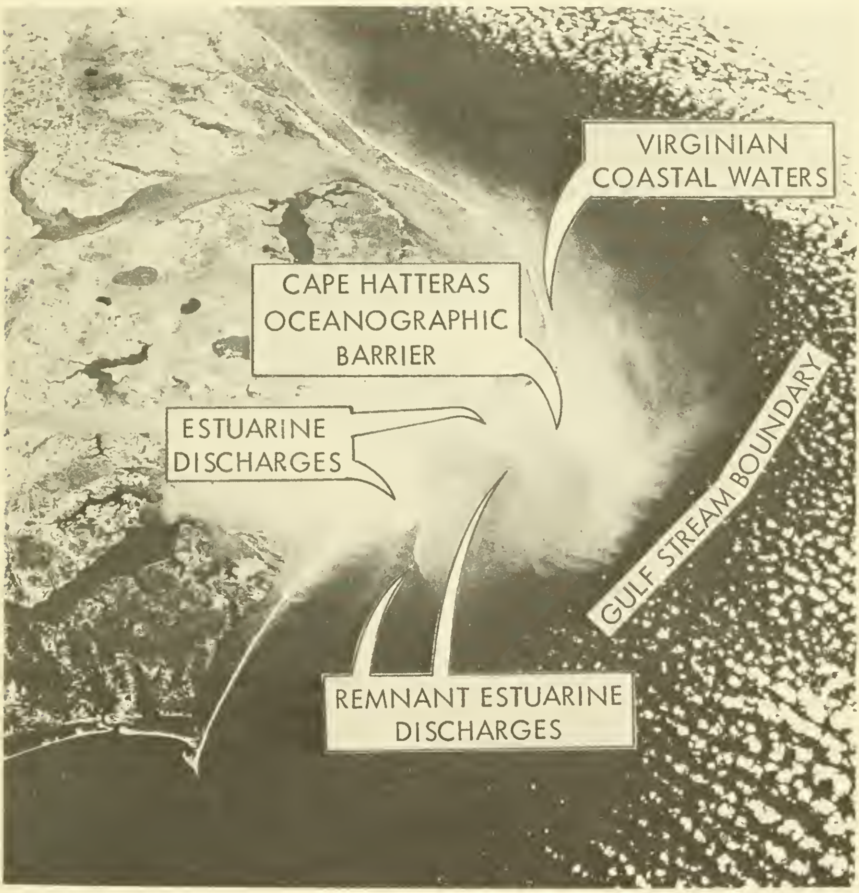
Year	Legislation and governmental initiatives
1956	*First permanent Federal Water Pollution Control Act.* Extended and strengthened the 1948 law in areas of enforcement and research and initiated grants for construction of waste treatment works.
1958	*River and Harbor Act.* Authorized a comprehensive project to provide for control and erradication of obnoxious aquatic plant growth in navigable waters, their tributaries, and allied waters in 8 States.
	Fish and Wildlife Coordination Act. Requires consultation with the U.S. Fish and Wildlife Service and the responsible State agency whenever the waters of any stream or body of water are controlled or modified.
1961	*Federal Water Pollution Control Act Amended.* Further strengthened enforcement authority and increased support for construction of municipal waste treatment works and research; authorized storage of Corps of Engineers and other Federal reservoirs for the regulation of stream flow for the purpose of water quality control.
1965	*Water Quality Act, further amending the Federal Water Pollution Control Act.* Established a Federal Water Pollution Control Administration in Department of Health, Education, and Welfare. Required establishment of water qualty standards for all interstate and coastal waters.
1966	*Clean Water Restoration Act, further amended Federal Water Pollution Control Act.* Greatly increased authorizations for grants to help build sewage treatment plants, for research, and for grants to State water pollution control programs. Transferred administration of the Oil Pollution Act from the Secretary of the Army to the Secretary of the Interior.
	Reorganization Plan No. 2. Federal Water Pollution Control Administration transferred to Department of the Interior under President's Reorganization Plan No 2.
	Executive Order No. 11288. Required all Federal agencies to comply with provisions and standards of Federal Water Pollution Control Act and cooperate with the Department of the Interior and State governments in preventing or controlling water pollution.
1969	*National Environmental Policy Act.* Enunciated policy to create and maintain conditions under which man and nature can exist in productive harmony, established the Council on Environmental Quality in Executive Office of the President, provided for annual Presidential environmental quality report, and specified need for interagency cooperation.
1970	*Executive Order 11507.* Strengthened requirement for all Federal agencies to comply with the Clean Water Act, the Federal Water Pollution Control Act and the National Environmental Policy Act in prevention, control and abatement of air and water pollution at Federal facilities.

Source: Federal Water Pollution Control Administration, U.S. Army, Corps of Engineers, Commission on Marine Science, Engineering and Resources.

The Federal Government has responsibility for national leadership in preserving the marine environment, defining national policy and objectives for managing the coastal areas and for assisting the States in developing and implementing planning. The Federal Government furnishes support and guidance for scientific research and training and services such as flood control and beach restoration; it also issues permits for uses and modifications and monitors the development and physical conditions in the coastal areas.

In line with this role the Federal Government is acting to strengthen the

existing Federal and State capabilities for preserving the marine environment. On February 10, 1970, in his environmental message to the Congress the President outlined a comprehensive 37-point program to guide the Nation in restoring the environment. Important sections of the message were devoted to water pollution. The Government has proposed legislation to encourage States to assume a greater responsibility for planning, regulating and managing their coastal areas, and has ordered immediate steps to reduce air and water pollution caused by Federal projects and installations. It has authorized additional expenditures for water pollution control. The Council on Environmental Quality was established by legislation to insure that all programs and actions are undertaken with a careful respect for the needs of environmental quality, and a Cabinet Committee on the Environment was created to coordinate Federal activities in the environmental field and ascertain that environmental considerations are taken into account in programs of Federal agencies.



Water discoloration shown in Apollo 9 photographs of Cape Hatteras indicates tidal estuarine discharges from Pamlico Sound, N.C. Remnant plumes from the previous ebb flow, a southerly flowing Virginia coastal current, and the Gulf Stream boundary, are also clearly visible in the photograph.

The responsibility for preventing and controlling water pollution and managing coastal resources rests mainly with State and local governments. While these governments are demonstrating greater interest in water pollution control, coastal development and resource management, many have not yet developed fully adequate machinery to meet their needs. Recent legislation proposed by the Administration would provide Federal assistance and support establishing administrative machinery, enforcement powers and authority.

Industry, business, and agriculture also share the concern for our water resources.

Acting To Preserve the Marine Environment

The mounting international and domestic concern for environmental preservation and restoration can provide a useful stimulus to inspire the actions to save the marine environment from harm. Most of the deep ocean today appears to be still largely undamaged by pollution. But the most used, productive and valuable part—the coastal tidelands—is suffering damage in places, the source of which is frequently river and estuarine pollution.

Our impact on the marine environment must be regulated so that the coastal areas and the deep ocean can be preserved, developed and used for our continuing benefit. This can be accomplished through comprehensive management, beneficial use, protection and development of the coastal areas employing Federal, State, and local governments and public and private interests. This does not mean that the ocean need be maintained in its primeval purity. It is clear that the seas can and will be used to absorb some waste products. The guiding principle should be to manage the marine environment so as to permit optimum, balanced use of the environment by recognizing and accommodating the diverse, competing private and public interests while at the same time preserving the quality of the coastal environment and conserving its resources. Such an approach will hold open options for various future uses.

The elements of such a management program should include mutually agreed policy, objectives and functions; legislative authority to carry out the program; basic knowledge for effective management; planning and implementation provisions; regulation, control and coordination authority; financial and manpower resources; and public awareness and acceptance.[4]

Science and technology become valuable tools in such a management program. To apply laws and regulations wisely to the natural environment requires an understanding of what natural conditions govern that environment, and how man's activities affect them.

Basic scientific information enables us to define the ecological base from which we operate; to understand the natural forces at work; to predict the

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[4] Elements of such a national approach to managing the coastal waters and adjacent land are outlined in the U.S. Department of the Interior's Federal Water Pollution Control Administration study entitled "The National Estuarine Pollution Study, A Report to the Congress," Nov. 3, 1969 and the Report of the Commission on Marine Science, Engineering and Resources, "Our Nation and the Sea," Washington, D.C. January 1969.

harmful and beneficial consequences of man's activities on the environment. From this comprehension, we can employ better engineering and technology to maintain water quality, control beach erosion, and create modern ports and harbors. With such information, we can generate criteria to define options and make choices among alternative regulatory actions, public and private uses of the seas and coastal lands, and costs. This information is fundamental to the political decisions needed to manage the environment.

We still lack much of the knowledge needed to provide the understanding required to assess and predict the effects of man-induced and natural modifications of the marine environment. In the absence of this information about the ocean's ability to absorb stresses and remain healthy, human activities may generate transformations that destroy, perhaps irreversibly, desirable properties of the marine environment.

The scientific information required includes establishing baselines or standards from which we can detect and measure environmental changes which may occur over the next 10, 20, or 50 years. We need to know what pollutants and in what quantities are entering the ocean; how much pollution the marine environment can absorb without substantially harming other uses; how marine pollutants circulate and disperse, degrade, and convert to other chemical and physical forms; and what effect man's physical modifications of the coastline have on water dynamics, marine life and sedimentation. Much remains to be learned about how pollutants enter the life cycle of marine organisms and what effect they have on them; and about how to treat ocean pollutants. An adequate pollution monitoring system could furnish information which would provide the scientific basis for assessing and predicting man-made changes, identifying and controlling pollutant buildup, managing waste disposal and safeguarding the physical and biological quality of the oceans.[5]

The planned approach to preserving and enhancing the ocean environment underlies the President's five-point marine science program of October 19, 1969, which calls for deliberate action to encourage States to plan for and manage the land and water resources of their coastal zones; to provide assistance in research required for sound management of their coastal zones; to begin a lake restoration program directed toward understanding the actions that would be required to reverse unfavorable trends in the quality of our Nation's lakes; and accelerate ocean-related research on the interaction of man with the Arctic environment. Recognizing the need to initiate international action, the program proposes a world-wide environmental quality program as part of the International Decade of Ocean Exploration.

This approach recognizes that the ocean and its resources are limited and vulnerable and that through careless use of technology we can gravely damage them. It also recognizes that by acting wisely now we can still preserve the ocean, its air, water and life for future generations.

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[5] A useful discussion of the needs of a worldwide system of ocean pollution monitoring is contained in "Global Ocean Research," a report prepared by the Joint Working Party on the Scientific Aspects of International Ocean Research nominated by the Advisory Committee on Marine Resources Research of the FAO, the Scientific Committee of Oceanic Research of the International Council of Scientific Unions and the WMO Advisory Group on Ocean Research, Ponza, Rome, and La Jolla, Calif., 1969.

Chapter III

ENHANCING THE BENEFITS FROM THE COASTAL ZONE

Thirty States, with more than 75 percent of the Nation's population, lie on the coasts of the Atlantic and Pacific Oceans, the Gulf of Mexico, and the Great Lakes. More than 45 percent of our urban population lives in coastal counties, and almost all of the major megalopoli now projected for the year 2000 are in the coastal zone—the margin where land and water meet and interact.

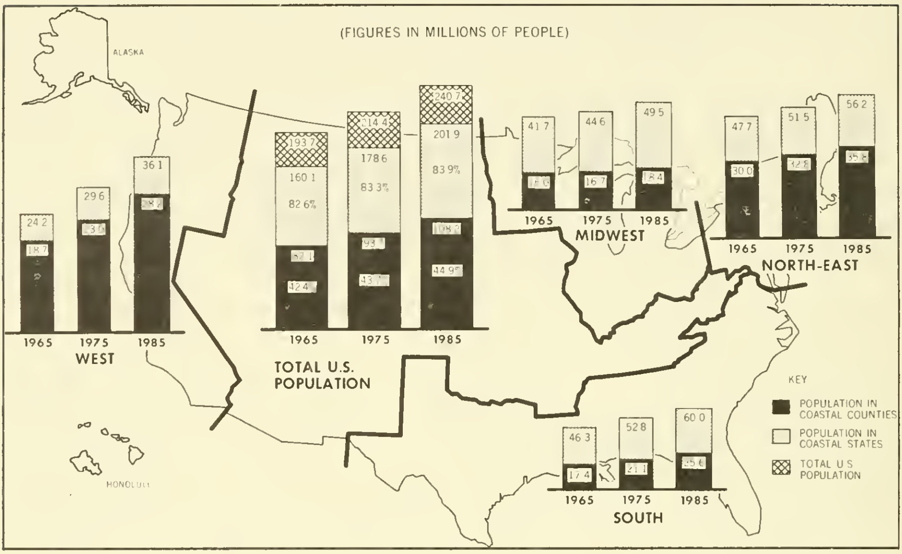
Shipbuilding, maritime commerce, and the fishing industry could have developed only in the coastal zone. Our naval strength and our seaward thrust for offshore oil, gas, and minerals must be based there. Many industries have found it advantageous to locate there because of proximity to ocean transport, labor, and produce markets. With their growing leisure time and disposable income, the American people increasingly seek the esthetic benefits of the coastal zone—its climate and opportunities for swimming, sport fishing, and boating. Tens of millions live or vacation at coastal resorts, retirement homes, and beach cottages. Millions more regularly head for beaches on weekends. Many others find business opportunities there. Figure III-1 exemplifies the increasing demand for coastal recreational facilities.

In the early stages of a shoreline's development, a few small, individual actions by users may have relatively little effect on the ecology, and upon other potential users. As the extent of usage grows, the environment is increasingly modified, often in ways which are reversible only with difficulty. Further, as early users become entrenched, later ones may find themselves preempted. As examples, dredging, filling, and coastal construction have already impaired the capacity of large areas to support fish and wildlife; municipal, industrial, and agricultural wastes have turned many rivers into open sewers, and altered the ecological balance of the estuaries into which they flow; and the limitations imposed by extensive private ownership have sharply reduced public access to beaches at a time when a growing and increasingly affluent population demands more recreational opportunities.

The diversity, magnitude, and significance of activities in the coastal zone require that many diverse interests must become involved in its management, if balanced multiple usage is to be assured, and further degradation of the environment avoided. This participation includes private landowners, and industries which occupy coastal sites; conservation and recreation interests;

The Santa Barbara oil spill spread to the California coastline. A second well is being drilled from the ship in the bottom of the photo to intercept the original well.

Figure III-1—Population Growth in Nation's Coastal Zone



and government at all levels—local, State, and Federal. Despite the obvious advantages to be gained, however, coastal lands and waters have not often been subjected to effective planning. In too many cases development has been oriented toward immediate and single-purpose uses of short-range economic advantage, with little thought being given to broader, long-range considerations.

These varied, growing, and often conflicting demands on the coastal zone have already created, in many areas, an urgent need to correct past abuses and insure optimum usage in the future.

Because of the diversity of coastal zone activities in which the Federal Government has a responsibility, almost every member and observer agency of the Marine Sciences Council is directly concerned with some aspect of the coastal zone. For purposes of clarity, their various functions and activities are presented below in a summarized and abridged form:

Department of the Interior:

- Office of Water Resources Research.
  - Administers programs in the study of water supply and of resources which affect water.
- Bureau of Commercial Fisheries.
  - Carries out programs to maintain maximum fisheries resource production, and to maintain a vigorous fishing industry.
- Bureau of Sports Fisheries and Wildlife.
  - Conducts programs to assure the perpetuation and enjoyment of sportfish and wildlife resources.
- National Park Service.
  - Administers and promotes the use of natural, historical, and recreational areas in the national park system.

Department of the Interior—Continued

Bureau of Mines.

Conducts programs to develop mineral resources and promote safety in mineral industries.

Geological Survey.

Conducts surveys and research in geology, topography, and mineral and water resources; classifies land as to mineral character and resources; provides engineering supervision for power permits; enforces regulations applicable to oil and mining leases.

Bureau of Land Management.

Administers or participates in administration of mineral resources on Federal Lands.

Bureau of Outdoor Recreation.

Promotes outdoor recreation and natural beauty programs.

Federal Water Pollution Control Administration.

Administers programs to enhance the quality and value of water resources, and to prevent and abate water pollution.

Department of Defense.

Department of the Navy.

Conducts and supports programs in marine research, surveys, engineering, production, and operations to enhance our national defense capability. Produces navigational charts and publications and some prediction services for mariners. Provides a national capability for salvage operation.

Department of the Army.

Conducts work and research to improve and conserve rivers, harbors and waterways, to protect shorelines and to prevent flood and hurricane damage; conducts mapping and charting in support of these functions. Provides data to users of ports and waterways. Administers the program of permits for construction in rivers and coastal waters.

Department of Commerce.

Environmental Science Services Administration.

Conducts research, surveys and production concerned with describing, understanding and predicting the state of the oceans, atmosphere, and earth.

The Maritime Administration.

Supports research programs in shipbuilding, ship operations, and ports, harbors, and marine terminals as they relate to the needs of commercial shipping.

Department of Health, Education, and Welfare.

National Institutes of Health.

Conducts research programs related to human health and disease as related to the marine environment.

Food and Drug Administration.

Administers research and regulatory activities related to the health and safety aspects of marine foods and drugs.

Department of Transportation.

Coast Guard.

Conducts research and development leading to improved systems for marine search and rescue, merchant marine and recreational boating safety, pollution, and polar transportation.

Atomic Energy Commission: Conducts and supports programs related to the effects of atomic energy matters on the marine environment.

National Science Foundation: Supports research programs to increase our basic and applied knowledge of the oceans through the National Sea Grant Program, supports coastal zone research in scientific, engineering, and social aspects, training and dissemination of information.

National Aeronautics and Space Administration: Conducts and supports programs to improve our ability in remote sensing of the environment.

Smithsonian Institution: Conducts research on basic oceanography and ecology.

Agencies that are not members of the Council, but have major responsibilities relating to land and other resources of the coastal zone, include the Departments of Agriculture, and Housing and Urban Development. Most Federal agencies conduct or sponsor activities in the coastal area.

Initiatives To Meet Needs of Coastal Development

In recognition of both gravity and urgency, the administration's five-point program to strengthen the Nation's marine science activities includes three areas–coastal zone management, undertaking coastal zone research, and lake restoration—which are directly concerned with coastal zone problems. The other two, the International Decade of Ocean Exploration, the Arctic studies have many elements which bear on these problems.

Coastal Zone Management

Increasing urbanization, a growing population with higher incomes and leisure time for recreation, and expanding industrial development have imposed greater demands for use of the coastal margin and Great Lakes. Without planned and controlled development, aided by better knowledge of the ecological impact of development, the natural coastal environment may be jeopardized and future options foreclosed. There is a manifest national interest in the effective management, beneficial use, protection, and development of the land and water resources of the Nation's estuarine and coastal zone for the following reasons:

1. The pressures of population growth and economic development impose an increasing number of conflicting demands upon the finite resources of the coastal zone.

2. Estuaries, marshlands, and other parts of the coastal zone contain extremely valuable habitats for fish and wildlife which move beyond State boundaries; such areas are vital to the life support of a major part of the Nation's commercial and sport fisheries harvest; such areas, particularly the

Green Harbor, at Marshfield, Mass., has been improved by the Corps of Engineers through a cost-sharing project with local interests. Expansion and deepening of the channel, construction of breakwaters, and provision of better wharf facilities now make the harbor much more useful both to recreational and commercial fishing craft.

estuaries, constitute ecological systems which are susceptible to destruction and disruption by man.

3. Continued uncoordinated development activities in the coastal zone pose an immediate threat of irreversible harm to the coastal zone and its resources and a loss of the benefits it offers.

4. The coastal zone is a valuable area for multiple economic, recreational, and resource uses.

5. The interest in the coastal zone extends to the citizens of all States, and is not limited to the citizens in the coastal States.

Legislation is required to provide policy objectives and authorize Federal grants-in-aid to encourage States to assume greater responsibility for planning and management of their coastal areas. The administration's proposal for such legislation has been introduced in the House as H.R. 14845, and in the Senate as S. 3183. Two types of grants would be authorized: (*a*) for initial development of planning and regulatory mechanisms; and (*b*) for implementation of the management plan. The latter grants would be approved by the Secretary of the Interior, contingent on the State having designated a single agency to receive management plan grants; having organized to implement its management plan; and having demonstrated that

the agency or agencies have necessary regulatory authorities to implement the plans.

The management plan should include—

(1) An identification of the boundaries of the portions of the State subject to the management plan;

(2) An identification and recognition of the national, State, and local interests in the preservation, use, and development of the coastal zone;

(3) A feasible land and water use plan, consistent with applicable water quality standards, within specific sections of the coastal zone, reasonably reflecting the needs of industry, transportation, recreation, fisheries, wildlife, and natural area protection, and residential development and other public and private needs, taking into account both short-term and long-term requirements;

(4) A description of the coastal States' current and planned programs for management of its coastal zone consistent with the management plan;

(5) An identification and description of the means by which the management plan and other resource use and management plans at the Federal, State, and local levels in which the coastal State is represented or is a participant concerning use, conservation, and management of the coastal zone will be coordinated, including the relationship of the management plan to State, interstate, and regional comprehensive planning as appropriate;

(6) Procedures for adequate review of State, local and private projects for consistency with the management plan;

(7) Procedures for furnishing advice as to whether Federal and federally assisted projects are consistent with the management plan;

(8) Procedures for modification and change of the management plan, including public notice and hearing;

(9) Evidence that the plan was developed in cooperation with relevant Federal agencies, State agencies, local governments, and all other interests;

(10) Procedures for regular review and updating of the management plan;

(11) Adequate provisions for disseminating information concerning the management plan and any subsequent modifications or changes therein; and

(12) Provision for conducting, fostering, or utilizing relevant research.

The recommended program would—

(1) Provide for balanced use among diverse private and public interests, while preserving the quality of the coastal and Great Lakes environment;

(2) Insure adequate coastal recreational opportunities and fish and wildlife habitats for present and future generations;

(3) Strengthen the States' capabilities to administer coastal natural resources that fall under their jurisdiction;

(4) Lessen the need for Federal intervention in coastal resource management decisions; and

(5) Provide greater integration of existing planning, conservation, and development programs, many of which are federally assisted.

The administration's proposed bill would authorize $2 million for the Department of the Interior in fiscal year 1971 to begin the program.

Approximately 23 Federal bureaus now interface with State coastal operations. The administration proposal would assign responsibility to the Secretary of the Interior for administering the Federal program, and for assisting in coordination of the activities of other Federal agencies.

Coastal Zone Research

Rational management decisions on use of the coastal zone should be predicated on scientific information as to the unwanted and often unanticipated effects of man's activities on the coastal ecology. Such comprehension of the dynamics of coastal ecology is today largely absent. So are assessments of the natural ecological baselines in terms both of the physical properties and the biological content of coastal waters and interaction with the land interface. Also, monitoring capabilities to detect the changes already occuring in water quality are too limited to meet needs.

The Federal Government already supports, through a variety of instruments mentioned earlier, important research on coastal zone problems, and funds for this program will be increased in fiscal year 1971 (See app. A). In addition, planning is underway under the leadership of the Department of the Interior to identify requirements for research related to coastal zone problems, and to assess the adequacy of existing Federal, State, and other institutions to provide the required research. This planning is expected to provide information needed to determine how existing capabilities can be better utilized and whether consolidation or discontinuance of activities may be required, or if new activities may be desirable, how additional research could be used by States in improving their management of coastal zone resources, what new activities are required, and how they should be funded.

Pilot Study of Lake Restoration

Our Great Lakes, lesser lakes, and many estuaries are exhibiting losses in water quality that destroy their value for various uses—unfortunately at the same time use demand is sharply increasing. The prolific growth of obnoxious weeds and algae scums that induce eutrophication, then transformation into a marsh, eventually wipes out natural wildlife. Because early signs of pollution are subtle, public reaction usually does not occur until the pollution becomes advanced. By this time, it is difficult to slow down the process, let alone reverse it.

Both corrective and prophylactic measures are needed. Yet marine pollution has so many causes—municipal sewage, industrial wastes, common chemicals (e.g., pesticides, herbicides, fertilizers, antiknock compounds, etc.), oil spillage, etc.—that technical prescriptions are difficult to formulate which are both effective and economical. Moreover, those having technical merit may be politically unpopular. Acceptance could be facilitated through a demonstration project.

To determine the feasibility of restoring the quality of some of the Nation's seriously damaged waters, existing technology should be tested on small bodies of water and new methods developed to establish the most practical and economical means for proceeding with the major task. The Department of the Interior has the responsibility for developing a lake restoration program and $1 million has been requested in the fiscal year 1971 budget to accelerate these efforts.

Work is already proceeding under the auspices of the Federal Water Pollution Control Administration for research on some portions of the problem. These include nutrient removal, nutrient deactivation, flushing of lakes after nutrient control measures, dredging of sediments to prevent reinoculation of nutrients, weed harvesting, and aeration of the lake water body.

This research has been going forward in Lake Erie as well as in several smaller lakes in Minnesota, Wisconsin, Maine, and Washington. It is expected that small bodies of water will be selected for further study and treatment as part of a demonstration project.

Program for the Great Lakes

The Great Lakes system—five huge, interconnected bodies of water—is a unique component of the coastal zone. The lakes are fresh, but their vast size subjects them to oceanic scale forces; their shorelines vary from almost virgin wilderness to highly concentrated metropolitan complexes; 25 million people, and 25 percent of our national industry are in the basin, yet the waters themselves are international in character. Although the Great Lakes escape some of the problems created by a saline, open-ocean environment, others more than replace them, and only Lake Superior is relatively free from deleterious effects.

Because of the regional and international aspects, environmental planning and resource management are extraordinarily complex. The United States and Canada join forces through the Great Lakes Fishery Commission and the International Joint Commission, while the Great Lakes Basin Commission, the Great Lakes Regional Commission, and the Great Lakes Compact Commission deal with regional matters within the United States.

The Marine Sciences Council sponsored studies during 1969 both through its Committee on Multiple Use of the Coastal Zone and by contract, on several phases of the subject. The Committee's Great Lakes Panel completed a report which identified major administrative and managerial issues.

Another study [1] contrasted the problems of multiple use of the coastal zone in two extreme cases—Lake Superior and Lake Erie.

During 1969, the Federal Water Pollution Control Administration in cooperation with the Coast Guard increased surveillance of the Great Lakes for water pollution, gave nearly $16 million in grants for the construction of urban sewage treatment plants, and joined with eight States in pollution enforcement actions. Major research efforts concentrated on finding ways of cutting down nutrient input which contributes to eutrophication. It also put its resources to work on combating DDT, thermal pollution, feed lot wastes and stream water runoff. During 1969, the Administration invoked the Oil Pollution Act of 1924 for the first time in the Great Lakes to remove thousands of gallons of oil from a ship abandoned in Lake Huron.

A pilot dredging study investigating the effects of dredging practices on water quality was completed by the Corps of Engineers. Studies to determine the effect of the disposal of polluted dredged materials in the open waters of the Great Lakes were continued by the Corps of Engineers with FWPCA directed primarily at determining the need, feasibility, and cost of various alternative procedures for disposal, containment, or treatment of solids removed during a dredging operation. The Corps also initiated a program of measurements of wave forces on monolithic breakwaters in the Great Lakes. Development of engineering and technology continued on the design and construction of works to control lake levels and to compensate for larger navigation channels.

The Bureau of Commercial Fisheries completed a 4-year pesticide monitoring program to assess pesticide contamination of estuarine and Great Lakes fishes. Results show that the threat to fishery resources is chronic, affecting reproduction in the food chain. The pesticide monitoring program provided much data to the Bureau and other agencies to determine the steps to be taken to control pesticide pollution of the Great Lakes. It also provided information techniques suitable for reducing the pesticide content of various species. This undoubtedly prevented a more drastic decline in use of Great Lakes fish during the increased concern over pesticides caused by the Food and Drug Administration seizure of Lake Michigan coho salmon.

Close surveillance is being made by BCF scientists of the response of fish populations to changes in the aquatic environment of Lakes Michigan and Erie. As an example, the Bureau in collaboration with the Department of Fisheries of Canada continued work on sea lamprey control under the direction of the Great Lakes Fishery Commission. Intensive studies of the distribution of the herring-like alewife, and development of methods to predict and reduce the intensity of heavy dieoffs were carried out.

Enhancing Water Quality

Maintenance of water quality is one of the most critical problems in the coastal zone. Pollution alters the ecological balance, and frequently alters

[1] "The Role of Marine Sciences in the Multiple Use of the Coastal Zone of Lake Erie and Lake Superior."

it for the worse. Dirty water is incompatible with goals of recreation. While in many of our lakes and rivers pollution has reached the crisis level, the ocean has fortunately not yet arrived at this stage; we still have the opportunity to forestall future blunders.

This situation challenges government and industry to take prompt and wise action. The Federal Water Pollution Control Act calls for the enhancement of the quality and value of the Nation's water resources and for the prevention, control, and abatement of pollution by establishment of water quality standards for interstate and coastal waters. The Secretary of the Interior has given substantially complete approval to the standards developed by the States. Primary responsibility for the enforcement of these standards rests with the States; if they fail to act, however, the Federal Government may bring suit against polluters.

The Clean Water Restoration Act of 1966 (Public Law 89–753) provides for grants to States, municipalities, or intergovernmental bodies for assistance in developing projects to demonstrate advanced methods of waste treatment and discharge control. The act also provides for a comprehensive study of estuaries, including impact of population and economic development on water quality. In response to these requirements the National Estuarine Pollution Study has been completed by the Federal Water Pollution Control Administration in collaboration with other Federal agencies, State and local governments, and industry and scientific representatives. To make readily usable the vast amount of information an automated storage and retrieval system was developed which contains data on over 850 estuaries. Ninety percent completed, this inventory will be finished in early 1970.

The report discusses the present state of knowledge on the estuarine zone, and proposes study and research programs to fill the identified gaps. It analyzes the biophysical and socioeconomic aspects of the estuarine zone, and presents recommendations for a comprehensive national program of estuarine and coastal zone management, using multiple long-term use of the estuarine environment as the common denominator.

The vital roles of State, local, and regional groups, as well as public and private interests, are recognized, and many responsibilities are suggested for them. The primary Federal responsibility is identified as leadership in the definition of policies and objectives, and support, both directly and by the activities of its agencies, to others involved in estuarine work. Against that backdrop, the Federal role was defined as—

(1) Providing impetus and progressive improvement of the national program through appropriate legislation;

(2) Providing continuing support and guidance to the States through grants, cooperative activities, technical advice and assistance, provision of services, promotion of interstate cooperation, advice on management policies, and public information programs;

(3) Completing and maintaining the broad national inventory of estuaries and coastal areas;

(4) Continuing broad estuarine and coastal studies not of a local nature;

(5) Participating in local and regional studies where appropriate;

(6) Exercising regulatory authority in such areas as enforcement of

water quality standards and other controls over pollution and maintaining controls over certain uses or modifications of the estuarine zone;

(7) Coordinating Federal estuarine and coastal management activities, and providing means for integrating these with those of State, local, and regional agencies;

(8) Monitoring developments in coastal areas and evaluating the effectiveness of the national program—in cooperation with States; and

(9) Assuring adequate consideration for the protection of estuarine values in the formulation of river basin development programs by recognizing the impacts of upstream water quality and related land resource development on the estuaries.

Specific recommendations for legislation and other action to carry out the national policy and achieve these goals were submitted in the study.

The National Multi-Agency Oil and Hazardous Materials Pollution Contingency Plan of 1968 established a pattern for a coordinated response among the Departments of the Interior, Transportation, Commerce, Defense, and Health, Education, and Welfare, and the Office of Emergency Preparedness in the event of a pollution emergency. The Department of the Interior is responsible for administering, developing, and revising the plan. Through national and regional plans, the expertise of all agencies involved are brought to bear in case of an emergency.

The plan provides for a National Inter-Agency Committee concerned with plans and policies for response to pollution incidents. It develops procedures for the coordinated reaction not only of Federal agencies, but also State, local, and private groups. The Committee reviews regional plans, reports on the handling of major or unusual incidents, and makes recommendations on training, research, equipment stockpiling, and other matters to assure preparedness.

A National Operations Center is maintained as are several regional centers. The National Center monitors reports of pollution incidents received from regional operations centers. If an incident exceeds the capability of a regional group, is interregional, or becomes a major hazard to life, property, or national security, a National Joint Operations Team can be activated to provide advisory assistance and coordination.

Actual direction of pollution control efforts during an incident rests with a predesignated on-scene commander. The Coast Guard is assigned the responsibility of furnishing on-scene commanders for coastal waters, the Great Lakes, and major inland navigable waters; the Department of the Interior will provide commanders for other areas. Response to a pollution incident may pass through several phases, depending upon the severity of the situation. Initial discovery and notification may be followed by containment and countermeasures; cleanup, restoration, and disposal; and finally, recovery of damages and enforcement.

Santa Barbara Oil Spill

A recent example of the plan in action was offered in the activity following the Santa Barbara offshore oil spill.

No single pollution incident during the year attracted as much public attention and posed such urgent and complex technical problems as the leakage of oil and gas from an offshore well near Santa Barbara, Calif. Because of this, and as an example of the national pollution contingency plan in operation, an overview of the sequence of events follows:

Calendar of events—1969:

Jan. 28	Gas blowout occurred at about 5½ miles from Santa Barbara. Coast Guard notified; initial efforts made by company to curb the flow.
Jan. 29	12-mile-long thin slick south of platform, ½-square-mile heavy slick near well, use of chemical dispersants commenced. Efforts to curb flow unsuccessful. District disaster control plan implemented under commander, Coast Guard Group, Santa Barbara, as on-scene commander. Meetings with State, local, and Federal officials.
Jan. 30	Slick spreading, but not to beaches. Oil booms activated at some locations. Application of low toxicity chemical dispersants began.
Jan. 31	First oil reached beaches. Commenced application of dispersants from boat equipped with booms. Wildlife treatment center set up.
Feb. 1	Oil reaching beaches, but still light; main slick thickly packed in a 1-mile triangle around well. FWPCA ordered application of chemical stopped due to possible toxicity. Additional tugs, barges, and booms called in.
Feb. 2	Drilling operations commenced to slant a relief well into the original hole. Efforts to contain the oil by booms at the well failed due to heavy weather. Oil on beaches continued light.
Feb. 3	Recommended chemical dispersants. Different boom fabricated to contain the oil near the well. Use of log booms, and of straw and other coagulants started off beaches; additional inflatable booms positioned in coastal areas. Beaches still essentially clear of oil; heavy slick 2 miles off Santa Barbara Harbor.
Feb. 4	Weather deteriorating; crude oil arriving on beaches at Santa Barbara.
Feb. 5	Attempts to seal well still unsuccessful. Weather stormy; efforts to contain oil at source suspended. Beach cleanup attempts intensified. Chemical dispersant discontinued except in vicinity of well.
Feb. 6	Weather continued bad; oil coming ashore heavier concentrations.
Feb. 7	Well sealed off; weather moderated; beach cleanup expanded.
Feb. 8	Flow ceased; most of oil already ashore, but some slicks still offshore, which soon dispersed to small weathered patches. Beach cleanup continued.
Feb. 12	Oil seepage started again; containment, skimming, and chemical dispersal resumed near well. Submersible survey of bottom near platform unsuccessful.
Feb. 16	Slick extending to within a mile of beach; much trapped in kelp beds.

Feb. 17	Production of oil authorized from shallow zones to relieve pressure causing seepage.
Feb. 24	Following stormy period, new oil deposits on beaches.
Feb. 25	Increased seepage. Chemicals, skimmers, and containment attempted.
Mar. 2	Efforts made to seal fissure leaks.
Mar. 4	Flow somewhat reduced.
Mar. 6	Slick consisted of streaks of oil extending southeast of platform; chemical dispersants continued.
Mar. 7	Dispersants discontinued. Flow much reduced.
Mar. 18	Dispersants and skimming continued for several days near well. Estimates are that small seepage may persist for some time.

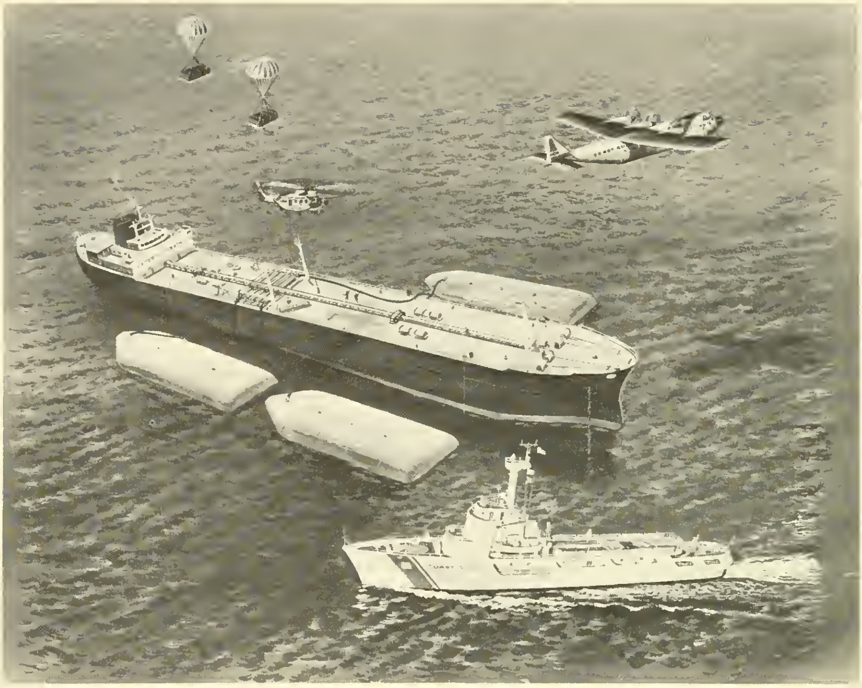
In retrospect, there was a degree of success in almost all corrective efforts, but none were fully adequate. Chemical dispersants were variable in their action; sinking agents were not generally successful. Containment booms were adequate in some cases, but much engineering development remains to be done to provide a fully effective system in rough water. Floating skimmers worked well in seas up to 6 feet high; beyond this, their efficiency rapidly decreased. Beach cleaning continued to be a major problem, especially on rough, rocky stretches.

Following this incident, a Presidential Panel was convened which reviewed the problem of oil spills and related matters. In its first report,[2] which was primarily concerned with prevention and correction of oil spills, the Panel noted that the United States does not now have sufficient technical or operational capability to cope with a large-scale oil spill in the marine environment. It recommended further action, including steps to reduce the probability of spills, research toward better control methods, and several administrative, regulatory, and legal changes to improve the overall situation. It was also suggested that an advisory team, including experts in ecology, environmental science, engineering, and economics to assist during an incident and the followup analyses and assessment, be made available.

In its second report the Panel considered the management of offshore resources, and their exploitation with lessened danger of pollution. It suggested that a Resource Advisory Board be established to advise on development of resources, and that the views of State and local government bodies be incorporated into plans for development of Federal offshore mineral resources. The possibility of placing some resources in escrow for future development was raised, as well as the need for more stringent regulations, for production methods as circumstances warrant. The desirability of unitized production and of underwater production facilities when feasible were recognized. A shortage of personnel and information in Federal agencies concerned with these matters was noted, and corrective action recommended.

Another step to insure the safer development of offshore mineral resources on Federal lands was taken by the Secretary of the Interior in August with approval of new regulations governing oil and gas leasing and development operations on the entire U.S. Outer Continental Shelf from Maine to Alaska.

[2] "The Oil Spill Problem," First Report of the President's Panel on Oil Spills; and "Offshore Mineral Resources—A Challenge and an Opportunity," Second Report of the President's Panel on Oil Spills; Office of Science and Technology, 1969.



The Coast Guard has sponsored development of an air-deployable system of collapsible containers and related oil transfer equipment. This system is designed to off-load oil from ships in distress to avoid spillage and contamination.

This represented the first revisions since the Outer Continental Shelf leasing program was begun 16 years ago. The new rules contain strengthened provisions for—

(1) Full consideration of all environmental factors, including aquatic resources, esthetics, and recreation, before a decision is made to offer leases for sale (features of this process provide that public hearings may be held and that there may be consultation with State agencies, organizations and individuals);

(2) Suspension of any operation, including production, which in the judgment of the Geological Survey's regional oil and gas supervisors threatens life, including aquatic life, property, mineral deposits or the environment;

(3) Prior review and approval by the supervisor of plans and equipment for the prevention of pollution, blowouts, and leakage, before drilling may begin either for exploration or development;

(4) Prior review and approval of exploration, drilling, and development plans in detail before work may begin which include location of wells; platforms and structures; proposed pipelines; and the lessee's interpretation of undersea geologic structures;

(5) Stiffer technical requirements for well drilling, casing, and cementing to prevent environmental contamination and to maintain control of wells;

(6) Frequent activation of blowout prevention equipment to test for proper functioning;

(7) Prompt reporting of leakage or spills to the Coast Guard and the Federal Water Pollution Control Administration, in addition to the Geological Survey's regional supervisor; and

(8) Control and total removal of the pollutant, wheresoever found, at the expense of the lessee, in case of pollution damaging or threatening to damage aquatic life, wildlife, or public or private property.

The combined effect of these improvements—both technological and managerial—will be to progressively lessen the likelihood of spills such as that off Santa Barbara, and to assure quick containment and correction if they do occur.

Research and development projects currently underway looking toward technological improvements include the following:

Design and fabrication of a prototype air-delivered transfer pumping and storage system is in progress and field tests are underway. The objective is to provide a quick-response capability to remove bulk oil from a stricken vessel before it is spilled.

Investigations are in progress on the utility of ultraviolet to infrared, and microwave sensors, for possible use in all-weather, direct reading, airborne detection of oil spills.

Investigations are being carried out on techniques to permanently sink oil slicks through the use of chemically treated sand.

An engineering study is in progress to establish design criteria for the development of containment booms for use on the high seas.

San Francisco Bay

"San Francisco Bay is an irreplaceable gift of nature that man can either abuse and ultimately destroy—or improve and protect for future generations." This introductory statement sets the theme of the San Francisco Bay plan, produced by California's San Francisco Bay Conservation and Development Commission. In carrying out its studies, the group drew on the knowledge of public, industry, local, and State groups, as well as the Corps of Engineers, Federal Water Pollution Control Administration, and the Public Health Service.

During 3 years of deliberation, the Commission produced 23 volumes of technical reports in addition to its final plan. The group concluded that the San Francisco Bay complex could serve human needs to an even wider degree than it does now, but that programs of development, modification, and correction must be developed on a regional rather than a local basis.

A major tool in the planning and implementation of such programs will be the Corps of Engineers model of the bay. This scale model, equipped to reproduce and measure pertinent phenomena including tides, currents, salinity content of the water, and shoaling of the bottom, provides an excellent test bed for advance evaluation of activities contemplated for the area. During the past year, extensions to the model were completed incorporating the delta of the Sacramento-San Joaquin Rivers.

The hydraulic model now includes all the delta waterways south of Sacramento, west of Stockton, and north of Tracy; all of Suisun, San Pablo, and San Francisco Bays; and more than 200 square miles of the adjoining Pacific Ocean.

During the year, using the expanded model, the Corps in collaboration with other agencies initiated studies of San Francisco Bay and the Sacramento-San Joaquin delta area for water quality and waste disposal. The search for solutions to these specific problems will consider the total impact of all competing needs, such as flood control, navigation, salinity control, water supply, tidelands reclamation, and recreation.

The Corps of Engineers also initiated an in-depth study to prepare a plan to guide the development of the entire bay region. By balancing present and potential users against the environmental resources of the area, a range of alternatives will be established from which Federal, State, and local interests can choose those most prudent and fruitful for the benefit of the greatest number.

Chesapeake Bay

The Chesapeake Bay offers a range of problems and possible solutions that may furnish guidance for work in similar estuarine and coastal environments. The Corps of Engineers, with the assistance of the Chesapeake Bay Study Advisory Group, representing State and Federal agencies as well as a wide variety of disciplines, has refined and extended its earlier investigations. A detailed plan has been prepared for a comprehensive study, construction of a hydraulic model of the bay, and an associated research center.

Multidisciplinary research activities in the technical center would concentrate on hydraulic and ecological studies. The physical model of the bay, supplemented by mathematical models and conventional analysis, would help to provide a fuller understanding of the physical and biological traits of the bay, and the insight necessary to properly manage the system in consonance with man's rapidly increasing involvement in the Chesapeake environment.

Conservation and Recreation

The National Park Service now includes 22 areas contiguous to the coastline—13 national parks and monuments and nine national seashores and lakeshores.

In addition, the Service administers 28 historic areas located along the coasts. Most recently authorized for incorporation into the system are: Biscayne National Monument in Florida and Redwoods National Park which includes a 30-mile stretch of the California coast. Feasibility studies were made in other proposed marine areas. Acquisition of National Park Service lands is continuing, including areas located in the coastal zone such as Assateague Island National Seashore, Biscayne National Monument, Indiana Dunes National Lakeshore, and Pictured Rocks National Lakeshore.

Many countries are expressing concern for the perpetuation of their unique underwater resources for scientific purposes and for underwater visitor observation. This interest is reflected in the number of countries which have created or are considering the establishment of underwater national parks and marine preserves. During the year, the National Park Service provided encouragement and information on this subject to many nations including: Japan, Thailand, Korea, Taiwan, Australia, New Zealand, Costa Rica, Colombia, Canada, South Africa, Tanzania, and Greece.

The National Wildlife Refuge System now includes 91 refuges in the coastal zone containing 20.4 million acres devoted to management of migratory birds and other wildlife, including the preservation of endangered species. Of these, 10 refuges containing 19.8 million acres are in Alaska. Approximately 13,000 acres were acquired during fiscal year 1969 under the accelerated wetlands acquisition program.

The Bureau of Outdoor Recreation plays a central role in promoting Federal-State cooperation and coordination to provide recreational opportunities, including those in the coastal zone. Also statewide outdoor recreation plans have been prepared by all States, many of which provide for meeting marine-related recreation needs and the preservation of coastal areas. Based on these plans, the Bureau has assisted over 4,000 State and local outdoor recreation projects, many of which are located in the coastal zone.

The Army Corps of Engineers makes substantial contributions to both conservation and recreation through its research studies and development programs for beach erosion control, shore protection, flood control, hurricane barriers, intercoastal waterways, interoceanic canals and boat harbors. An example of the research field studies undertaken by the Corps is the experimental groin structure at Point Mugu, Calif., which provides a capability for conducting controlled experiments on shore processes. Corps of Engineer planning assists the State and local governments in the development of plans by providing data, information and guidance regarding water resources, and marine sciences development proposals. Additionally the Corps cooperates with State and local governments in having beaches restored or improved for public use; natural barrier beaches and shore areas bolstered by sand fill, fences, vegetation and structures; and small boat harbors developed for recreational and fishing boats.

The National Shoreline Study was commenced by the Army Corps of Engineers, in cooperation with State and Federal agencies. The study, which will cover both private and public coastlines, will identify those areas in which shoreline erosion poses serious problems to economic and recreation uses, and to ecological and other relevant factors. It will also propose generally the appropriate type of remedial actions for areas with serious erosion problems. The study will serve as a basis for the development of guidelines by Federal, State, and local agencies for the optimum uses of shores subject to erosion, but will not include recommendations for authorization of specific projects.

More than 20 million people now participate in recreational boating in coastal waters, and the Coast Guard estimates an increase of over 200,000 boats per year on our waterways. Boating has become an important factor

in our economy, accounting for $3 billion in related expenditures in 1969. An increasing demand for marinas, harbors, aids to navigation, and protection is clearly evident. Working toward safer recreational boating, the Coast Guard has negotiated 39 agreements for Federal/State safety program coordination; legislation has been proposed providing for a national boating safety program for small boat construction and performance and for assistance to State programs. ESSA assists the small boat enthusiast through its nautical chart program and marine weather forecasts.

The Fish and Wildlife Service, as a part of its total program, provides information pertinent to a wide range of recreational and conservation problems. As one example of its contribution to multi-use development and management in the coastal zone, during 1968 it screened some 5,100 applications for construction permits and found that approximately 5 percent of these would have adverse effects upon fish and wildlife resources.

The Bureau of Sports Fisheries and Wildlife continued its wide-ranging studies supporting recreational fishing. Its marlin and sailfish tagging program has traced the migration of these species throughout the Pacific. Experiments aimed at creating artificial fishing reefs have shown that scrap tires are the best materials, being easy to handle, attractive to fish and related organisms, durable, and not producing deleterious decay products.

Coastal Projects of Federal Agencies

The programs of the Federal agencies, often carried out in collaboration with State and local governments, are aimed toward a sequential approach to coastal problems. It is first necessary to gather facts on the coastal zone, to provide the data base from which further research and affirmative action start. This includes not only mapping the coastline and adjacent waters, but also the establishment of ecological baselines. From this information, research projects to provide a better understanding of the situation, and to develop techniques for corrective measures can be developed. Pilot projects to test the efficacy of these measures can then be run as a prelude to full-scale coastal improvements. A sampling of these interrelated activities not covered in other sections of the report, include the following:

1. A 2-year project of monthly determinations of concentrations of iron, manganese, and zinc in estuarine sediments and water was completed by the Geological Survey. This will serve as a valuable baseline to evaluate possible changes from radiation pollution.

2. Engineering studies are being carried out by the Coast Guard, working toward the development of booms to contain oil spilled in the open ocean, and for the design and fabrication of an air-transportable, high-capacity pumping system, and emergency tankage, to quickly remove oil from a troubled vessel before spillage. Prototype testing of the latter system is scheduled for 1970.

3. The adverse effects of sewage sludge dumping in the New York bight are being investigated by the Corps of Engineers and the Bureau of Sport Fisheries and Wildlife. The Corps has completed a pilot study of the possible harmful effects of dumping polluted dredged materials in the Great Lakes. This study is now under review.

4. Through its pesticide monitoring program in both ocean and Great Lakes, the Bureau of Commercial Fisheries determined levels of pesticides in shellfish, crustacean, and fish stocks. This information can be used to plan pesticide utilization compatible with continued harvesting of commercial species.

5. An ecological study of Biscayne Bay, Fla., is investigating the effects of thermal pollution from a nuclear powerplant on fish life. The Atomic Energy Commission is supporting the study of noncommercial species, and the Bureau of Commercial Fisheries those which are of commercial value.

6. A comparison of the ecology of a natural marsh area with that of a marsh altered by channeling and filling is being conducted by the Bureau of Commercial Fisheries in Galveston Bay.

7. The Corps of Engineers published a study on methods available for the analysis of physical and ecological problems in estuaries.[3]

8. Numerical models and prediction programs to forecast storm surges along the coastline have been developed and tested by ESSA and Navy.

9. Acute (96-hour) toxic effect of several new pesticides on oysters, shrimp, and fish were evaluated by the Bureau of Commercial Fisheries under controlled conditions in the laboratory. Information obtained from these and other toxicity studies was sent to the Pesticide Registration Division of the Department of Agriculture to aid it in certifying pesticides to be used in the marine environment.

10. The Corps of Engineers published an engineering analysis of the coastal engineering aspects of the tsunami wave created by the Alaskan earthquake of 1964.

11. Following up an earlier initiative of the Marine Sciences Council, the Corps of Engineers sponsored a study on the effects of engineering activities on coastal ecology.

Opportunities for the Future

The coastal zone, with its multitude of opportunities, also presents a multitude of problems. Many of these are largly scientific and technological, and to these our scientists and engineers can provide answers. Far more difficult questions arise from the conflicting desires and needs of the many different occupants and users of the shoreline. The challenge before us is to reconcile these competing interests—to find opportunities for multiple, compatible uses of the shoreline and inshore waters, and to maintain options for future uses not foreclosed by degradation of the resource.

This will require identifying multiple compatible uses and also encouraging the development of effective mechanisms for making rational choices among incompatible uses. Implementation of those initiatives of the administration's five-point program which relate to the coastal zone should assist in making available both the basic information and the management tools for making wise decisions.

[3] "Guidelines for Evaluating Estuary Studies, Models, and Comprehensive Planning Alternatives," Department of the Army, August 1969.


MANHATTAN

Chapter IV

FACILITATING TRANSPORTATION AND TRADE

Waterborne transportation—lake, canal, coastal, and intercontinental—is an integral part of the U.S. national economy and is essential to the support of defense requirements. However, while about 90 percent of our foreign trade cargo moves by sea, U.S.-flag vessels carry less than 6 percent of this total, and projections indicate that this percentage may decline even further.

While only one-fourth of the world's merchant ships are more than 20 years old, approximately three-fourths of American merchant ships are at least that antiquated. In the next 4 years, much of this aging merchant fleet will be scrapped. Yet, the United States is now producing only a few new ships a year for use in our foreign trade. Building costs for American ships are approximately twice those of foreign shipyards, and U.S. production delays are often long. Operating expenses also are high by world standards, and labor-management conflicts have been costly and disruptive. Figure IV–I indicates the trends in numbers and tonnages of the world's major merchant fleets.

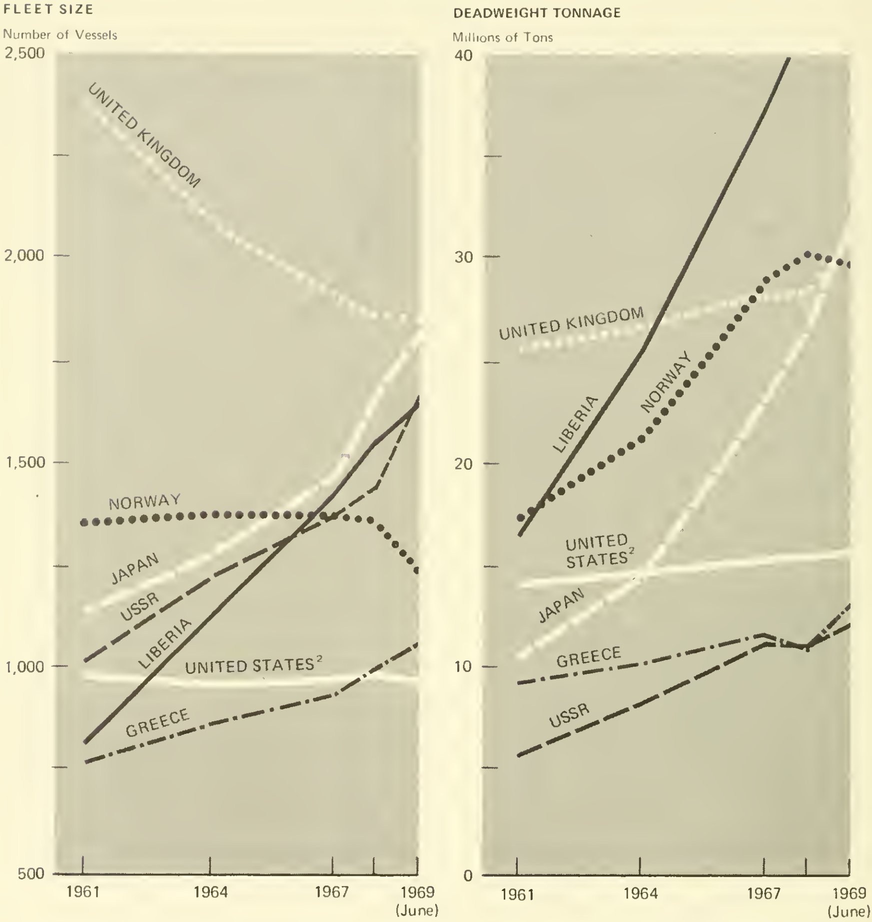
Policy To Improve the Merchant Fleet

The President, in a message to the Congress in October 1969, recognized the seriousness of the situation confronting the U.S. merchant fleet and proposed a 10-year corrective program which he described as a program of challenge and opportunity for all segments of the maritime industry. Noting that both Government and industry must work together to rebuild the U.S. merchant fleet, the plan which was outlined to accomplish this aim would not increase subsidy expenditures during the current fiscal year. By emphasizing multiyear commitments and standardized ship types where feasible; it is expected that U.S. production rates can be accelerated, and costs per unit reduced. The President expressed confidence that the shipbuilding industry could meet the challenge; however, it was also indicated that if the challenge were not met, then the subsidy portion of the administration's program would not be continued.

Construction of an average of 25 general cargo ships, three dry-bulk carriers, and two tankers per year for the 1970's is planned, although the

Humble's icebreaking tanker SS Manhattan *completed an historic transit of the Northwest Passage in 1969. Data gathered during voyage will permit evaluation of the potential of the Arctic as a commercial shipping route.*

Figure IV–I–Merchant Fleets of the world



1 Oceangoing stream and motor ships of 1000 gross tons or more Excludes ships operating exclusively on inland waterways and special ships such as channel ships, icebreakers, military ships, etc

2 Only privately owned U S ships are included U S. government ships, excluding the reserve fleet, rose from 64 vessels in 1961 to 171 vessels in 1967 but this largely reflects activation of reserve ships for war duty

Sources Merchant Fleets of the World, 1961, 1964, 1967, 1969, Maritime Administration, U S Department of Commerce

annual "mix" of ships may vary. These ships, added to 150 already under construction or planned, will provide an overall increase of 450, and will exceed the capacity of the present merchant fleet. The total of $3.8 billion of Federal subsidies over the decade will be matched by $4 billion from industry. Supporting this investment program, it is proposed that the ceiling on federally insured mortgages be increased from $1 billion to $3 billion. Construction differential subsidies will be extended to bulk carriers, which are not now covered, and construction subsidies paid directly to shipyards.

In operational support for the merchant marine, differential subsidies will be continued only for the higher U.S. wage and insurance costs. Under the plan, it is proposed that the "recapture" provisions of earlier legislation which required that a portion of profits be returned to the Government would be eliminated, as would the statutory requirement that certain Gov-

ernment cargoes be shipped in U.S. ships at premium rates. These arrangements would be replaced by a new, direct subsidy system for such carriers. Port and harbor development will be accelerated, in cooperation with industry and local government authorities.

Research and Development Supporting Maritime Activities

In support of this strong Federal policy for the merchant marine, the maritime research and development program will be enlarged and redirected to place greater emphasis on practical applications of technological advances, and the cooperation of Government and industry. Stronger attention is given to science and technology that can assist in improving our worldwide competitive position, supporting national defense, and reducing Government support costs.

Under the Ship Structure Committee, which is an interagency advisory committee chaired by the Coast Guard, the *Wolverine State,* an instrumented C–4 SB–5 cargo ship, in conjunction with towing-tank model studies and computerized stress programs, has provided naval architects with information to improve ship structure design and allow greater variation in design. These reports cover subject titles such as "Bending Movement Determination," "Ship Statistics Analysis," "Rational Ship Structural Design," "Hull Girder Model Study," "Chemical Tank-Barge Design," "Simulated Performance Testing," and "Quality Assurance."

The National Academy of Sciences-National Research Council is conducting a study on laws affecting manpower utilization, since there is a real need to review the laws under which merchant marine manpower policies operate, to determine the changes needed in view of current technology and the potential for the economic future growth of the industry. These restrictive regulations and laws, some of which have been in effect since 1792, were written to cover situations that no longer exist because of changed technology.

A National Conference on Maritime Research and Development was held at Woods Hole, Mass., with representatives from ship operators, shipbuilders, labor organizations, private research companies, universities, merchant marine training academies, port authorities, and Federal agencies. As a result of this meeting, many recommendations were made for research and development in maritime operations, such as—

(1) Ship construction methods;
(2) Ship operations and design;
(3) Cargo handling systems, both on ships and ashore;
(4) Port facilities;
(5) Integration of sea, land, and air transportation systems; and
(6) Fundamental technological advances not developed sufficiently for current applications;

Included in the above are—

(1) Shipbuilding cost reduction projects;
(2) Integrated steam propulsion systems;

(3) Improved hull structure design to reduce ship cost by about 20 percent;

(4) Additives to reduce ship resistance to water flow, yielding a 5-percent saving in operational cost;

(5) Steps toward automation of shipboard functions to reduce operation costs and to improve job opportunities for personnel;

(6) Development of a low-cost multi-application dry-bulk cargo competitive merchant ship;

(7) Measurements of sea wave spectra for improved ship design and seaworthiness predictions; and

(8) Utilization of higher strength steels, to reduce displacement by 15 percent, resulting in reduction in power requirements and operation costs.

The Departments of Commerce, Transportation, and Defense all support research and development efforts related to novel shipping concepts, marine equipment, and advanced ship design. Funding for these programs is summarized in table IV–I.

Table IV–1—Funding for Ocean Transportation

[In millions of dollars]

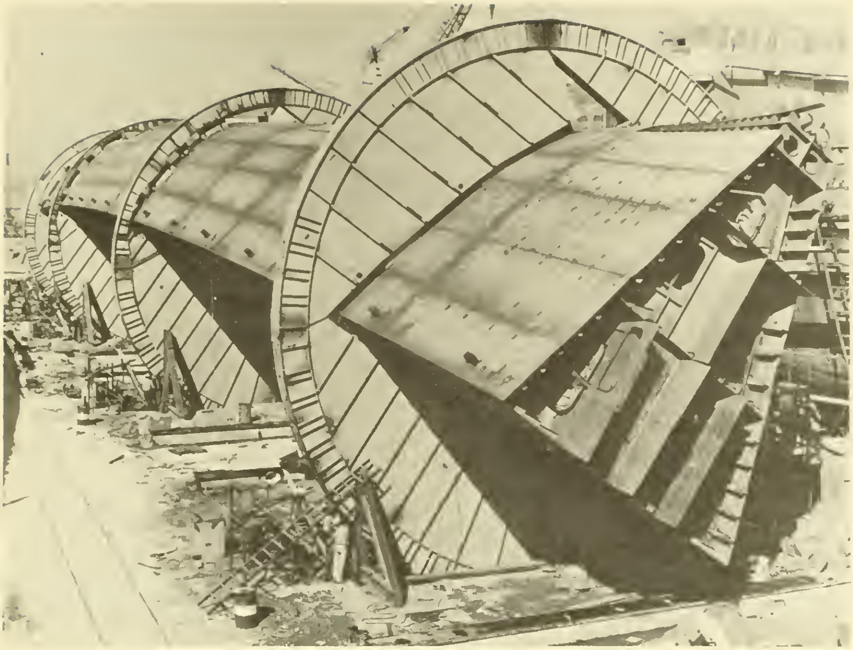
Activity and supporting agency	Estimated fiscal year 1969	Estimated fiscal year 1970	President's budget fiscal year 1971
Vessel and port technology [1]			
Department of Commerce (MARAD)	9. 2	16. 6	23. 2
Channel and harbor development research [2]			
Army Corps of Engineers	2. 7	2. 9	4. 1
Safety, navigation aids, pollution control [3]			
Department of Transportation (Coast Guard)	4. 8	10. 1	13. 6
Total	16. 7	29. 6	40. 9

[1] Limited to R&D and scientific services; excludes funding for capital works or maritime subsidies, operations, and routine services.
[2] Limited to R&D, feasibility studies, and Great Lakes data collection and analysis; excludes about $200 million for channels, harbors, and other projects providing navigation, shore protection, and recreation support.
[3] Pollution control does not include funds of the Department of the Interior (FWPCA). These are included as a part of "Water Quality Enhancement" under Development and Conservation of the Coastal Zone in app. A–1, and amount to an estimated $8.8 million in fiscal year 1969; $17.0 million in fiscal year 1970; and $16.4 million in fiscal year 1971.

In addition, these Departments also provide services in support of shipping, such as nautical charts, the costs of which are included in the appropriate funding tables of other chapters.

The Maritime Administration of the Department of Commerce is supporting a number of research and development projects bearing on ocean shipping problems. These include the following:

1. Research in maritime science and technology looking beyond the current state-of-the-art in search of basic technological breakthroughs which will raise the level of marine scientific knowledge and provide a better understanding of design and operational problems.



Ship construction is greatly speeded and simplified by a novel method used by Avondale Shipyards of New Orleans, La. The hull, mounted in huge rings, can be rotated to any angle, so that construction welding can be done working downward rather than overhead (men working in left foreground indicate scale).

2. Research in ship operations and shipping systems focused on social, economic, and technical problems involved in ship and terminal operation, and maintenance and cargo movement, such as labor displacement and changes brought about by containerization and other new shipping concepts; automation, man-machine relationships, and crew reduction; delays and damage of cargo while at terminals due to port congestion and intermodal transfer; and maintenance and reliability of shipboard equipment.

3. Advanced ship engineering and development covers engineering studies and development of hardware for ship, port, and feeder subsystems which are needed to produce and maintain lower cost, more productive ships, cargo handling and flow, and port operations.

4. Research on shipping economics and requirements carried out by systematic analysis of ship cargo movements from source to destination to determine the most desirable maritime system. This study incorporates technological advancements in ship design, ship operation, and cargo handling as they are developed, and forecasts estimated total system performance for shipping concepts under projected conditions.

Research and development related to ocean shipping carried out by other Government agencies includes the following:

1. A Polar Transportation Requirements Study,[1] completed and published by the Coast Guard. It considers the commercial, social, research, and

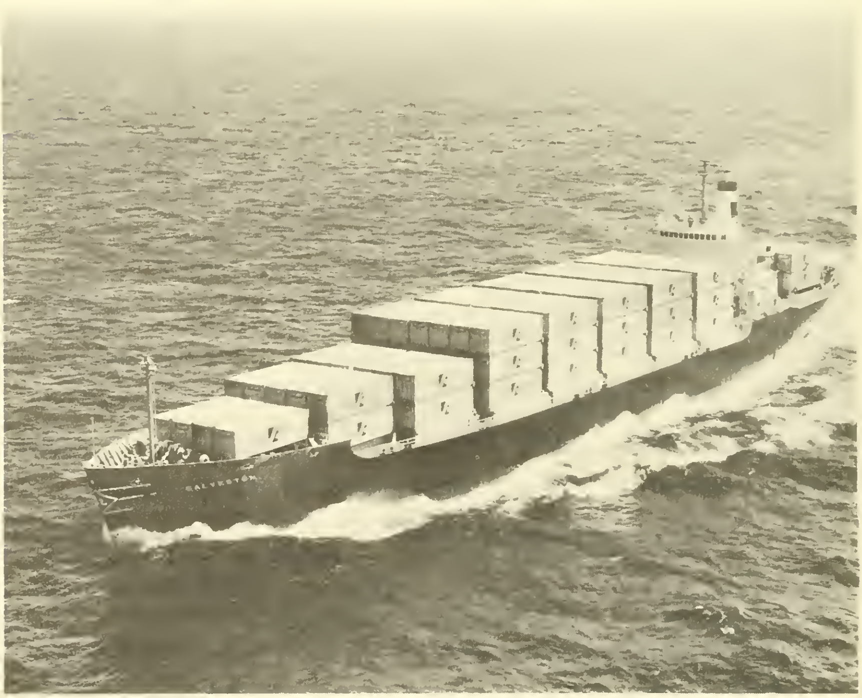
[1] "Polar Transportation Requirements Study Report," U.S. Coast Guard, November 1968.

national security aspects of this complex multinational area. Costs, benefits, and feasibility data for several transportation alternatives have been included in this study.

2. The Department of Transportation continued work on the development of a national navigation plan, which is considering present and future needs of both aviation and maritime commerce, and the technology of navigational satellites and ground-based electronics systems. The plan will identify areas of Federal responsibility for services, the systems to be operated, and the need for further research and development to meet future navigation requirements. Completion of this study is anticipated during 1970.

3. The Joint Surface Effect Ships Program, designed to determine the feasibility of building and operating large, fast surface effect ships in the 4,000- to 5,000-ton range, capable of 80 knots or higher speed. Major funding of this program will be assumed by Navy in fiscal year 1970; however, it will continue to be closely coordinated with the Maritime Administration of the Department of Commerce. Competitive contracts have been awarded for the detailed design, construction and test of two 100-ton test craft with differences in technological approach to permit a parallel testing and comparison program.

4. Development of guidelines for design approval and safety inspection of vessels and structures in the Arctic being carried out by the Coast Guard.



The SS Galveston, *operated by Sea-Land, Inc., is indicative of new developments in ship and cargo handling design. Containerized van cargo is loaded as large modules, permitting faster handling and more efficient space utilization.*

5. Design development of several new ship concepts, such as Navy's multipurpose dry cargo ship and the Maritime Administration's catamaran containership.

6. A study in depth by the Advanced Research Projects Agency of the Department of Defense of the military, commercial, and research potential of surface effects vehicles for Arctic use. An Arctic operational capability has been selected as a development goal since the potential impact of fast, long-range, high-payload transportation over open water, pack ice, and tundra is substantial.

American industry has also responded to the challenge of reducing costs by increasing ship speeds, by designing specialized ships and transportation systems, by building larger ships, and by investing funds in modern automated continuous-flow shipyards.

Attaining a competitively economic merchant marine is not being delayed primarily by a lack of technology, but rather by obstructions preventing application of existing technology. The Navy through its ship research and development programs, model basins, and laboratories has been in the forefront of advanced ship concepts. Although, for naval applications, improvement in performance is a strong requirement, the work that has been done can be applied, for merchant ship applications, for improvement in design criteria and earning capacity.

The ship channel at Galveston, Tex., was recently deepened and improved by the Corps of Engineers to accommodate larger vessels. Improvements of harbor and terminal facilities contribute to the increased efficiency of our merchant marine.

Transportation Support Services

Adequate channels, harbors, and terminal facilities are essential to efficient maritime operations, and accurate charts, publications, navigational aids, and environmental forecasts are basic requirements for safe navigation. In 1969, noteworthy supporting services provided by Federal agencies included the following:

1. The Coast and Geodetic Survey issued seven new nautical charts and 487 revised charts of U.S. waters. The U.S. Naval Oceanographic Office completed 110 new charts and over 700 revised editions of its worldwide chart coverage.

2. The "navigational lane" system was established by the Coast Guard and Coast and Geodetic Survey for the safety of shipping and installations, in New York and San Francisco Harbors, Delaware Bay, and the Santa Barbara Channel. This traffic control method provides merchant shipping with inbound and outbound lanes, with a buffer zone between them, in the approaches to major ports or congested coastal areas, to reduce the possibility of collisions.

3. The Army Corps of Engineers is studying the use of chemical explosives in harbor excavation. The first full-scale test of the technique is planned for 1970.

4. The Army Corps of Engineers has 53 coastal harbor and channel improvement projects underway, for which the Federal costs are estimated at $1,764 million. Another 98, to cost $1,672 million, have been authorized by Congress but not yet funded.

5. Looking to the future, the Corps of Engineers has studies in progress to determine the feasibility of improving harbors for deep-draft vessels at 92 ocean locations and 22 Great Lakes ports. Studies concerning harbor improvements for light-draft vessels are underway at 217 ocean locations, and 32 on the Great Lakes. Nineteen of these investigations have been completed during the past year. (Closely related is an independent assessment by the American Association of Port Authorities of future port requirements. This study will forecast the size and types of vessels which will be involved in U.S. trade during the next 30 years. Particular attention is being given to the problems created by supertankers and other large bulk carriers.)

6. The Coast Guard is extending its experimental harbor advisory radar coverage of the San Francisco area. A second radar station will cover the offshore approaches, supplementing the first station which now provides coverage of the harbor inside the Golden Gate. The stations observe and advise harbor traffic, thereby reducing collision hazards and speeding up traffic flow during poor visibility.

7. The Navy's optimum ship routing program which routes vessels by taking all environmental factors into account, is being further improved by being put into numerical model form to permit computer forecasting.

8. The Navy, ESSA, and Coast Guard have continued their long-range studies of the Gulf Stream, which are leading to better predictions of its behavior and effect on ship routing.

A number of national and international projects to improve safety at sea were underway in 1969. The United States signed the International

Convention on Tonnage Measurement, which will provide for the first time in more than 100 years uniform determinations of vessel tonnages. Coast Guard studies are in progress to achieve improved safety conditions on U.S. commercial fishing ships, and an investigation was completed to determine the proper Coast Guard role in promoting safety for civilian submersibles and for other nonmilitary underwater activity.

Arctic Voyage of SS "Manhattan"

As geophysical exploration and test drillings confirmed that Alaska's north slope contained major oil reserves, it became clear that a primary problem would be distribution of the oil to world marketing centers. Considering the geographical location, and the environmental conditions both at sea and on land, neither pipelines nor conventional tankers seemed entirely suitable for the purpose. As a result, for the first time in a century, serious consideration was given to the Northwest Passage as a trade route.

The Humble Oil & Refining Co., deeply involved in the Alaskan oil production, selected the SS *Manhattan,* already the largest merchant ship to fly the U.S. flag, for modifications preparatory to an experimental run from the east coast of the United States, through the Canadian Archipelago to the north coast of Alaska, and return. While her pioneering voyage—in itself one of the significant maritime events of 1969—provided a great amount of information on her own performance, the *Manhattan* was operating primarily as a test vehicle, looking toward the possibility of icebreaking supertankers of 250,000 deadweight tons.

The tanker underwent extensive modifications prior to her voyage. She was strengthened internally and sheathed externally against the tremendous forces to be expected in the ice pack, and a new bow designed for more effective icebreaking was installed. After conversion she had the following statistics: 115,000 deadweight tons, 1,005 feet length overall, 148 feet breadth 52 feet draft, and 43,000 horsepower driving twin five-bladed propellers—a far cry from John Cabot's wooden hulled sailing ships which in 1498 had first searched for a northern shortcut to China.

Because of the complex engineering and scientific problems which were anticipated, a large team of experts was assembled to prepare for and carry out the voyage. Scientific and engineering personnel, and experts in Arctic ship operations were provided by the Coast Guard, the Corps of Engineers, and the Navy, as well as by universities, industry, and the Canadian Government.

The *Manhattan* departed Philadelphia on August 28, 1969, and proceeded by way of Halifax, and Thule, Greenland. Almost immediately, she encountered extensive pack ice in Baffin Bay, and had a chance to shake down her equipment. At various times during the voyage she was assisted by the U.S. Coast Guard icebreakers *Northwind* and *Staten Island* and the Canadian icebreakers *Sir John A. McDonald* and *Louis St. Laurent.* On September 5 she entered Parry Channel and headed westward through the Canadian Archipelago in the "northwest passage."

Figure IV–2—Northwest Passage Track of SS "Manhattan"

The first severe test came as the *Manhattan* probed the heavy ice in McClure Strait, north of Banks Island. Winds sweeping across the open Arctic Ocean often jam the dense polar pack into the mouth of the strait, with heavy pressure and ridging, making it potentially the most difficult part of a transit. Faced with just this situation, the tanker was stuck in ice three times, and the decision taken to proceed via the more ice-free Prince of Wales Strait between Banks and Victoria Islands.

Proceeding via this alternate route she soon passed the Mackenzie delta and steamed up the Alaskan coast, arriving in sight of the drilling rigs at Prudhoe Bay on September 19. After onloading a symbolic barrel of Alaskan crude oil, she sailed on to Point Barrow, her successful westward transit completed.

On her return voyage the *Manhattan* spent almost a month in Melville Sound, deliberately seeking out different ice conditions. Maneuvering tests were run to see how large ships would perform under difficult circumstances comparable to those which would be encountered during much of the year. These tests concluded, she continued her eastward transit and arrived at New York City on November 12, having covered over 11,000 miles on the round trip.

During the entire voyage, the *Manhattan*'s extensive instrumentation continuously recorded data on the air, water and ice, and the ship's reaction to environmental conditions. In addition to the automatic equipment there was a wealth of visual observations and hand-recorded information,

as well as data from other ships and from aircraft. Once these data are analyzed, transportation experts will have a much better idea of what kind of ship is required to maintain year-round operations in the Arctic. Working from this baseline, factors such as capital investment, operating costs, the time factor, and cost of terminal facilities will be incorporated to arrive at a shipping cost per barrel, and a decision as to whether tanker transport of oil through the "northwest passage" is economically competitive.

It is, of course, far too early to label the voyage either a success or a failure. Many difficulties were encountered—the *Manhattan* herself was in difficulty in the ice several times, and had to call on icebreaker assistance; the icebreakers themselves had problems, and the *Northwind* had to be replaced; and the *Manhattan* suffered a hull rupture due to ice impact. Redesign of some hull characteristics will doubtless be required, and possibly further experimental voyages prior to actual decisionmaking. Alternatives, such as pipelines or submarine tankers, are still being considered.

While many of these final questions remain as yet unanswered, the *Manhattan*'s voyage made a significant contribution not only to U.S. competence in polar transportation, but to the Nation's knowledge of the Arctic regions in general. Perhaps most importantly, it stimulated new thinking about old problems, and may thereby point the way to other advances in the rapidly developing Arctic.

Looking to the Future

A strong and profitable merchant marine fleet, competitive in the world market, is an integral part both of our national and international economy. The administration's initiatives in this field, coupled with a vigorous response from industry, and supported by an imaginative program of research and development, will work toward the rapid achievement of this goal.

Chapter V

ENCOURAGING DEVELOPMENT OF MARINE MINERAL RESOURCES

An adequate, dependable supply of minerals and energy at a cost consistent with broader goals of economic growth, national security, and a healthy environment is essential to industrialized nations in today's world. Indeed, ascendancy to the ranks of "industrialized nations" is closely related to an ability to apply innovative technology to provide sustained supplies of fossil fuels and hard minerals. The United States presently consumes greater quantities of fuels and metals than any other nation.

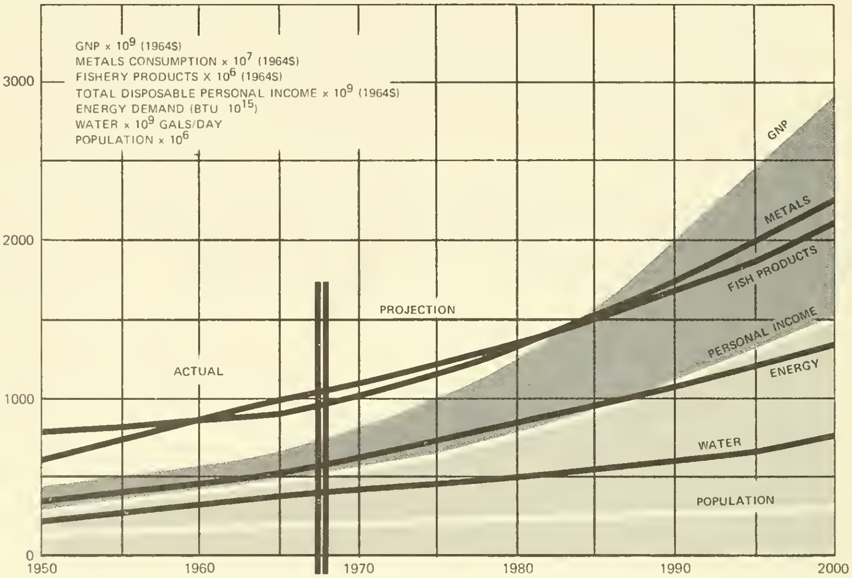
Consumption of metals and energy is closely related to gross national product as illustrated in figure V–1 which also projects a more than two-fold increase in U.S. demand for these commodities by the end of the century. Worldwide, the rapid growth of population and increased industrialization is intensifying competition for known mineral deposits and stimulating efforts to find new sources. The search for conventional high grade mineral deposits on land has thus been expanded to include an economic means of utilizing previously bypassed lower grade ores; developing new types of deposits, such as oil shale, tar sands, and taconite; and exploiting the resource potential of the seas.

The availability of sufficient resources within the oceans to meet the world's requirements for minerals well into the next century is acknowledged. The 330 million cubic miles of sea water have been described as the earth's largest continuous ore body, containing about 50 quadrillion tons of dissolved solids including, for example, 10 billion tons of gold. Large areas of the floors of the world's oceans are covered with nodules rich in manganese, copper, cobalt, and nickel, with concentrations of as much as 31,000 tons of nodules per square mile in some areas of the Pacific. And, recent estimates indicate that petroleum deposits under the sea floor may equal or exceed those on land.

However, statistics indicating the mineral content of the oceans often are misleading. An economy is no respector of mineral sources, and actual exploitation will continue to be dictated by economic considerations. At present, the cost of developing oceanic sources for most minerals is prohibitive in comparison to land deposits. Sea water is an extremely low-grade source for most of the 60 naturally occurring elements found in it and only magnesium, bromine, common salt and fresh water are commercially exploited in significant amounts. The important industrial metals such

During 1969, the first underwater petroleum storage tank, almost 100 yards in diameter, as high as a 20-story building, and weighing 15,000 tons, was towed to its working location and submerged in 158 feet of water in the Arabian Gulf.

Figure V–I—U.S. Annual Requirements for Natural Resources, 1950-2000



SOURCE DEPARTMENT OF THE INTERIOR

as aluminum, tin, copper, zinc, silver, iron, nickel, and manganese are valued at less than $1.05 per 1,000,000 gallons of seawater, and it has been estimated that the $20,000 worth of gold in a cubic mile of the ocean would cost more than $50,000 to extract. Deposits of manganese nodules, which were first discovered in 1875 during the epic voyage of the H.M.S. *Challenger,* remain noncompetitive with conventional ores due to the heavy investment required to mine the nodules from water depths of 12,000 to 20,000 feet and then to separate the extremely complex and unique mixture of metals. Oil and gas production, which constitutes over 90 percent by value of minerals extracted from the marine environment, has been limited to water depths of 340 feet and 70 miles from shore due to the rapidly mounting costs of moving into deeper waters.

Status of Marine Mining

Offshore mining is still in its infancy, but a pattern of increasing profitability and technological capability is emerging.

Ten years ago there were only three or four nations and about five companies with major offshore petroleum interests. Today, hundreds of companies are involved in subsea oil and gas exploration and development around the world. Production is underway or about to start off the coasts of 28 countries, and exploratory surveys are being carried out on the continental shelves of another 50. Offshore deposits are responsible for 16 percent of the oil and 6 percent of the natural gas produced by the free world. Projections indicate that by 1980 a third of the oil production—four times the present

Table V-1—Value of Mineral Production From Oceans Bordering the United States, 1960-69

[In millions of dollars]

Year	From sea water	From wells in ocean subfloors	From beaches seafloors	Combined
	Magnesium metal and compounds, salt and bromine	Petroleum, natural gas, and sulfur	Sand and gravel, feldspar and cement rock [1]	
1960	69.0	423.6	46.8	539.4
1961	73.0	496.6	46.2	615.8
1962	89.1	620.7	44.3	754.1
1963	84.6	730.8	42.5	857.9
1964	94.5	820.3	43.6	958.4
1965	102.6	933.3	51.4	1,087.3
1966	117.0	1,177.7	51.6	1,346.3
1967	113.8	1,450.9	55.9	1,620.6
1968	146.1	1,980.0	52.8	2,178.9
1969 (preliminary)	151.7	2,327.3	56.0	2,535.0
10-year total	1,041.4	10,961.2	491.1	12,493.7

[1] Shell and calcareous marl.

Source: Bureau of Mines, Department of the Interior, Dec. 30, 1969.

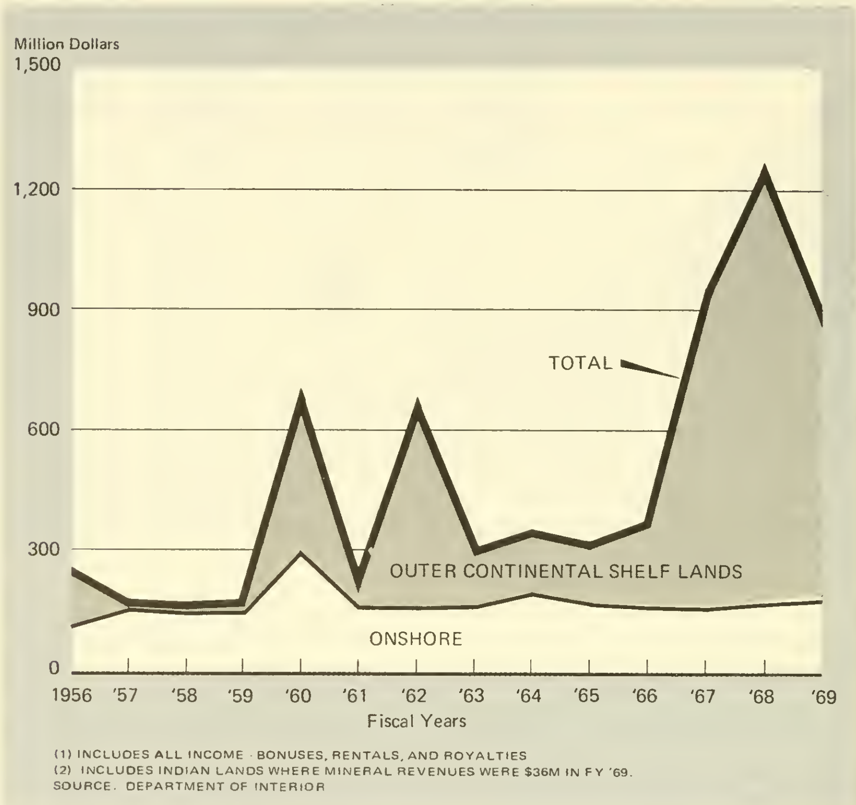
output of 6.5 million barrels per day—will come from beneath the ocean; the increase in gas production is expected to be comparable.

In the United States, where some 90 percent of the most favorable onshore areas have been explored as contrasted with less than 10 percent of the offshore shelf areas, subsea petroleum development is increasing rapidly. Since 1946, approximately 15,300 wells have been drilled offshore and it has been estimated [1] that 3,000 to 5,000 wells will be drilled annually by 1980. Over $13 billion has been invested by industry in exploration and development activities which have resulted in the production of $7 billion worth of oil and gas from the submerged wedge of sediments comprising the U.S. Continental Shelf, mostly off Louisiana. To date, the minerals industry has paid the Federal Government some $3.4 billion in bonuses to lease 6.5 million acres of the Outer Continental Shelf. All but $35 million of this was paid for oil and gas leases with the remainder going for rights to salt and sulfur. As shown in figure V-2, income to the U.S. Treasury from OCS lands in fiscal year 1969 totaled $714 million with bonuses accounting for $492 million; production royalties $214 million; and rentals paid on leased acreage $8 million. The reduction in receipts from the previous year is due in large measure to a temporary suspension of lease sales after the Santa Barbara blowout.

The ocean is a valuable source of a variety of mineral commodities, in addition to oil and gas, for a growing number of the coastal nations. Salt, bro-

[1] "Offshore Mineral Resources—A Challenge and an Opportunity"; second report of the President's Panel on Oil Spills; Office of Science and Technology, 1969.

Figure V-2—Comparative Revenues From Mineral Leases on U.S. Public Lands Onshore and on the Outer Continental Shelf



mine, magnesium, and both heavy (D_2O) and fresh water are extracted from the water column; sand and gravel, oyster shell, tin, heavy minerals, and diamonds are dredged from placer deposits on the sea floor; sulfur is recovered from the seabed by melting it with superheated water and piping it to the surface; and coal, iron ore, and nickel-copper ores are mined from the subfloor in shafts driven seaward from land. Coal extracted from undersea mines accounts for more than 30 percent of Japan's total production and more than 10 percent of Britain's. The value of minerals, both fuel and nonfuel, produced from the sea in 1969 on a worldwide basis was estimated to be over $7 billion (table V–2).

The ocean has become a significant source of several of the nonfuel minerals used in our domestic economy. Sulfur extracted from two mines off Louisiana constitutes 15 percent of U.S. production (and the bulk of the world's total offshore production) of this valuable industrial raw material. Recovery of chemicals from sea water, especially magnesium, bromine and salt, has doubled during the last decade, and some 50 million cubic yards of sand and gravel and 20 million tons of oyster shells are extracted annually from the U.S. Continental Shelf.

Table V-2—Worldwide Production of Mineral Resources From the Oceans in 1969

Resource	Percentage by value from ocean	Value (millions of dollars)
Seawater:		
Salt	29	$173
Magnesium metal	61	75
Fresh water	59	51
Bromine	70	45
Magnesium compounds	6	41
Heavy water (D_2O)	20	27
Others (potassium, calcium salts, sodium sulfate)		1
Total value from seawater		412
Seafloor (surface deposits):		
Sand and gravel	<1	100
Shell	80	30
Tin	4	24
Heavy mineral sands (ilmenite, rutile, zircon, garnet, etc.)	13	13
Diamonds	<1	9
Iron sands	<1	4
Total value of surficial deposits		180
Seafloor (subsurface deposits):		
Oil and gas	16	6, 100
Sulfur	4	26
Coal	2	335
Iron ore	<1	17
Total value of subbottom deposits		6, 478
Total		7, 070

Source: Department of the Interior; Dow Chemical Co.; miscellaneous.

Impediments to Progress

Advancement by the minerals industry offshore has been impeded by three interacting considerations—economical, technological, and institutional. The economic attractiveness of offshore ventures depends on a variety of factors: resource demand; competition from other sources; cost and effectiveness of marine operations; potential productivity of the deposits; and investment climate, including stability of operations. At greater water depths and distances from shore, costs rise rapidly. It is estimated that the capital cost to develop and produce from a 50-million-barrel offshore petroleum field will increase more than 100 percent when moving from 100 to 600 feet of water.

The petroleum industry has been singularly successful in moving offshore, combining the initial advantage of being able to adapt directly many onshore exploration-production capabilities with imaginative follow-on techniques for deeper water operations. Although current production is

limited to a water depth of 340 feet, exploratory drilling for oil is proceeding at depths of 1,500 feet in the Santa Barbara Channel. The report of the National Petroleum Council issued in March 1969, "Petroleum Resources Under the Ocean Floor," stated that progress of the petroleum industry offshore is limited primarily by economic attractiveness rather than by technological capability, and predicted that complete systems for exploration and production in water depths of 6,000 feet will be available within the decade.

Unlike oil and gas, marine nonfuel minerals have been relatively neglected due largely to the absence of an economic incentive sufficient to stimulate development of exploration and production capabilities. Worldwide, less than $250 million in hard minerals were recovered from the oceans last year in some 300 mining operations, all conducted close to shore (table V–3).

Table V–3—Recent Marine Mining Activities

Resource	Activity [1]	Depth (feet) [2]	Location
Aragonite	Dredging	100−	Bahamas.
Diamonds	Dredging	100−	Southwest Africa.
Gold	Exploration	200−	Philippines.
	Exploration	600−	Alaska.
Heavy metals	Exploration	200−	Australia.
	Exploration	100−	New Zealand.
	Exploration	100−	Tasmania.
Iron	Exploration	200−	Philippines.
Iron sands	Dredging	30−	Japan.
	Exploration	200−	Papua and New Guinea.
Manganese nodules	Exploration	1200±	Canada (B.C.)
	Exploration	12000+	Pacific Ocean.
Phosphate	Exploration	600±	Union of South Africa.
	Exploration	600–2400	Blake Plateau.
	Exploration	?	India
	Exploration (inactive)	600±	California.
	Exploration	600−	Australia.
Phosphate sands	Exploration	600−	Mexico.
	Exploration	600−	North Carolina.
Sand	Dredging	100−	New England.
Shell sands	Dredging	150±	Iceland.
Shells	Dredging	30±	California.
Sulfide muds	Exploration	6000±	Red Sea.
Sulfur	Mining (Frasch)	60±	Louisiana.
Tin	Exploration	200−	Borneo.
	Dredging	150−	Indonesia.
	Exploration	200−	Malaysia.
	Dredging	150−	Thailand.
	Exploration	200−	Great Britain.
	Exploration	200−	Solomon Islands.
Titanium	Exploration	200−	Philippines.

[1] Dredging operations generally include exploration activity. Does not include mines originating on land and drilled out under the sea floor.

[2] Less than is represented by −; more than is represented by +; approximately is represented by ±.

Source: Department of the Interior.

Identification of target areas for hard minerals mining is especially difficult since few deposits extend seaward from land, making tracing impossible, and most have small horizontal dimensions. Thus, more sophisticated exploratory techniques and equipment than used on land are required. Also, production of surficial minerals is limited to protected coastal waters less than 200 feet deep because of the lack of a deep-water, open-ocean dredging capability; tunneling for subfloor minerals is restricted to 15 miles from shore by the state-of-the-art of underground excavation techniques. Consequently, most experts believe that production of hard minerals in the near future will probably continue to be limited to nearshore areas unless unknown, extremely rich deposits are found in the deep ocean, or a sudden change in the availability of critical commodities dictates unusual measures.

Future discovery of valuable new sources of minerals in the deep ocean cannot be ruled out. Vast areas, including the longest and highest chains of mountains on earth—the mid-oceanic ridges and their associated rift valleys—are virtually unexplored. During separate expeditions in the Red Sea in 1964, 1965, and 1966, three undersea pools of hot, high-density, metal-bearing brines were found at depths of some 7,000 feet. Scientists from Woods Hole Oceanographic Institution, who have estimated that the brines contain over $2.3 billion in gold, copper, zinc, and silver in their top 100 feet, believe that the origin of the metals is related to a rift valley that cuts through the middle of the sea.

Despite economic and technological constraints on ocean mining, industry's most frequently stated problem—according to the report of the Commission on Marine Science, Engineering and Resources—is "the lack of a clear regulatory and legal framework for many aspects of marine operations. Industry also is handicapped by current and foreseeable conflicts over multiple use of marine areas and by lack of clear definition of the rights of individuals and companies to use coastal or offshore areas." In view of growing public reaction against the use of coastal waters for operations which pose hazards to water quality and marine ecology, and unresolved international issues on ownership of minerals of the deep ocean (see chs. III and XIII), institutional factors involving social, legal, and administrative considerations may be the major impediments to an expansion of marine minerals development in the 1970's.

Government's Role and Agency Responsibilities

Government's role with respect to mineral development has been to encourage and sponsor programs to—

(1) Insure an adequate, dependable, diverse supply of raw materials for an expanding population and for a growing industrial economy;

(2) Have available mineral supplies at lowest cost consistent with the satisfaction of other national objectives;

(3) Maintain a sufficient resource base for national security;

(4) Conserve the Nation's mineral resources by using them wisely and efficiently;

(5) Preserve the quality of the environment—air, water, and land—while obtaining the needed mineral resources:

(6) Maintain safe and healthful working conditions during mining and mineral processing;

(7) Manage the mineral resources of Federal lands in accordance with sound business principles;

(8) Manage U.S. mineral resources so as to assist in maintaining a favorable balance of payments;

(9) Provide supporting services such as mapping and charting, weather and sea forecasting, aids to navigation, ice breaking and channel maintenance, and rescue-at-sea activities; and

(10) Provide a climate for industry to produce efficiently under competitive conditions the minerals required for the domestic economy and foreign trade.

In carrying out this role, it is assumed that the actual production of the minerals from the sea as well as from land will continue to be accomplished by private industry.

Programs which directly and indirectly contribute to the development and management of marine minerals are conducted by a large number of Federal agencies and include—

(1) Resource mapping, delineation, and assessment to identify the general distribution and economic potential of seabed minerals—Geological Survey, Corps of Engineers, Environmental Science Services Administration;

(2) Leasing and management of federally-owned land—Geological Survey; Bureau of Land Management;

(3) Development of prototype mining and processing methods and systems prohibitively expensive for industry to undertake alone—Bureau of Mines, Office of Saline Water;

(4) Supply and demand analyses for minerals and fuels—Bureau of Mines;

(5) Supporting services such as bathymetric charting, geophysical surveys, logistic support, environmental forecasting, and safety-at-sea—Environmental Science Services Administration, Navy, Coast Guard, Corps of Engineers;

(6) Research on seafloor origin, structure, and processes fundamental to understanding and predicting mineral occurrences—National Science Foundation, Navy, Geological Survey;

(7) Administration of U.S. tax, customs, regulatory, and import-export policies—Departments of Treasury, Justice, and Interior, Federal Power Commission, Interstate Commerce Commission; and

(8) Participation in international negotiations on issues affecting marine mineral development—Department of State.

Coordination of these diverse but interrelated activities to serve industry, State and local governments, and the general public is accomplished through a variety of interagency mechanisms, most of which involve Executive Office overview by the Office of Science and Technology, the Council of Economic Advisers, the National Security Council, the Bureau of the Budget, and the Marine Sciences Council. Under the Marine Resources and Engineering Development Act of 1966 (app. B–2), the Marine Sciences Council is

responsible for assisting the President to insure that the marine science activities of the United States are conducted so as to accelerate development of marine resources and to encourage private investment in the requisite exploration, technological development, and economic utilization.

Programs of the Department of the Interior

The Department of the Interior, as the Government's primary agent for natural resources, carries out those Federal programs specifically directed at marine minerals development and management. To strengthen the Department's capabilities to deal with emerging and critical issues in the marine area, the Secretary of the Interior has named an Assistant Secretary for Fish and Wildlife, Parks and Marine Resources and created an Office of Marine Resources under the Assistant Secretary. During the last fiscal year, Interior funded marine minerals programs amounting to $8 million which were conducted by the Geological Survey, Bureau of Land Management, Bureau of Mines, and Office of Saline Water (table V–4).

Table V–4—Department of the Interior Programs in Direct Support of Marine Minerals Development

[In millions of dollars]

Activity and agency	Estimated 1969	Estimated 1970	Estimated 1971
Geologic investigations: Geological Survey	2.9	3.3	3.3
Mining research: Bureau of Mines	1.5	0.9	0.9
Leasing and management:			
Bureau of Land Management	0.3	0.5	0.5
Geological Survey	0.8	1.3	1.7
Fresh water sources and marine relationships:			
Office of Saline Water [1]	1.9	2.6	2.2
Geological Survey	0.6	0.6	0.6
Total	8.0	9.2	9.2

[1] Programs to develop and demonstrate desalting methods are not included.

The Geological Survey's program of marine geology involves geological and geophysical reconnaissance surveys and mapping of the U.S. continental margins to: identify and appraise target areas for potential new mineral resources; evaluate geologic and engineering hazards relating to the seafloor; and investigate geologic processes in the marine environment. The Geological Survey began concerted offshore mapping in 1962 by sponsoring a cooperative program with Woods Hole Oceanographic Institution on the Atlantic continental margin; this mapping effort has since been expanded to the Gulf, Pacific, and Alaskan coasts and includes research contracts with nine universities. Work is now proceeding on a time-phased program for completing a comprehensive geological analysis of the Nation's continental margins at a scale of 1:250,000 with periodic compilation of data from all available sources at 1:1,000,000 or smaller for planning purposes. At present, less than 10 percent of the mapping effort has been completed.

Priority areas to be mapped are selected by the urgency of the "need-to-know" in terms of assessing the economic value of lands to be offered for leasing, identifying geological hazards to construction activities, and locating potential new deposits of needed minerals to stimulate development by private industry.

Among recent Geological Survey marine programs are—

(1) Intermediate scale geologic mapping in the central Gulf of Alaska and on the Bering and Chukchi continental shelves to serve as a guide for the assessment of placer deposits of gold, tin, platinum, and oil and gas resources;

(2) Participation with the Coast Guard and ESSA's Coast and Geodetic Survey in "Polar Profile—1969," an oceanographic survey of the Chukchi Sea aboard the U.S. Coast Guard cutter *Storis* which identified geologic structures and sedimentary rock sequences possibly favorable for large accumulations of petroleum;

(3) Detailed geologic and hydrologic investigations of San Francisco Bay to assist in planning for land development and construction engineering in a seismically active area;

(4) A geochemical analysis of 1,400 bottom samples from the northwestern Gulf of Mexico which revealed anomalously high concentrations of zirconium, possibly indicating the presence of economically important heavy mineral occurrences;

(5) An extensive regional structural, stratigraphic, and geochemical survey of the Gulf of Mexico, conducted jointly with the Navy aboard the USNS *Kane* in concert with its military objectives, which demonstrated that geologic conditions are favorable for oil and gas beneath much of the Gulf; and

(6) Mapping programs off Boston to identify sand and gravel deposits, and between Cape Hatteras and Cape Fear to investigate the resource potential of that region.

In August 1969, the Geological Survey published four new maps plus an interpretive text which represent a major contribution to our consolidated knowledge of global marine mineral resources.[2] "World Subsea Mineral Resources" is a first attempt to summarize data on the occurrence of subsea minerals and to outline their location and extent throughout the world's ocean basins. Information and advice was provided by experts from industry and academia as well as from Federal agencies.

These preliminary maps were prepared at the request of the Marine Sciences Council as part of the Government's effort to assemble basic information helpful to its own officials and to those of other nations concerned with seabed exploration and development. Copies of the maps were presented to representatives of the United Nations Committee on the Peaceful Uses of the Seabed and Ocean Floor Beyond the Limits of National Jurisdiction at the opening of its session last August.

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[2] "World Subsea Mineral Resources" (preliminary maps); McKelvey, V. E. and Wang, F. H., U.S. Geological Survey; Miscellaneous Geologic Investigations, Map I–632, 1969.

The maps depict large-scale geologic provinces; known and potential distribution of petroleum, sulfur, phosphorite, managanese, metal-bearing muds, and saline minerals (fig. V–3); and sites of current mining, drilling, and dredging operations. The interpretive text notes that areas favorable for the local occurrence of subsea petroleum resources may be adjacent to nearly every coastal nation but adds that the geology and resources of the seabottom are still too imperfectly known for accurate appraisal of their magnitude and value.

Both the Geological Survey and the Office of Saline Water sponsor programs designed to use the oceans to augment conventional sources of fresh water. Office of Saline Water activities involve research and development related to purification of seawater and mineral recovery from concentrated brines. The Survey undertakes the collection and appraisal of basic water data; conducts research and mapping related to submarine springs and coastal aquifers; and investigates hydrology, hydraulics and sedimentation in selected estuaries. A study of offshore aquifers in Monterey Bay is currently being conducted in cooperation with State agencies.

The Bureau of Mines conducts studies of the U.S. consumption, domestic production, and reserves of more than 80 minerals, including examination of the economics of production from marine and alternative sources. The marine mining program of the bureau, carried out at its Marine Minerals Technology Center at Tiburon, Calif., is designed to assist in the development of resource sampling, delineation, and production equipment and techniques which are effective and reliable, and which afford maximum protection to the environment. Activities in 1969 included the testing of systems for automated precise position fixing and modification of subbottom profiling equipment to make it more suitable for delineation of marine mineral deposits. In addition, the analysis of data from an earlier survey of Coronado Bank phosphorite deposits revealed a significant correlation between high mineral concentration and specific physical characteristics of individual deposits. This suggests the possibility that the economic potential of other phosphorite deposits can be assessed on the basis of their physical properties.

Statutory responsibility for leasing and managing federally-owned offshore lands—the 805,000-square-mile Outer Continental Shelf—is vested in the Department of the Interior, specifically in the Bureau of Land Management and the Geological Survey. The Bureau of Land Management prepares leasing maps, holds lease sales, and approves assignment of lease interests. It also issues rights-of-way for pipelines and related facilities and, during the past year, completed a study on the place of offshore oil in the total national supply. In progress is a study designed to identify the economic impact of recent revisions in the regulations which govern leasing and drilling on the Outer Continental Shelf. The Geological Survey is the agent for gathering information on the geology and mineral resources of the offshore areas and for supervising resource production activities. The two bureaus work together to identify tracts to be offered for lease and development; to assess the economic value of the acreage for purposes of establishing acceptable bonuses; and to plan for long-term development of the OCS.

Figure V-3—World Subsea Petroleum Potential (preliminary map)

(Adapted from Sheet 3 of World Subsea Mineral Resources Maps, I-632, published by the U.S. Geological Survey, Department of the Interior, 1969)

The selection of offshore lands for leasing, determination of their fair-market value, supervision of drilling activities, and prevention of environmental degradation became focal points of nationwide attention last year. For the first time, the Secretary of the Interior revised the regulations governing leasing and the production of oil and gas on the Outer Continental Shelf. (See ch. III.) And, following the oil well blowout on a Federal lease in Santa Barbara Channel early in 1969, the President appointed an *ad hoc* Oil Spill Panel which subsequently issued two reports assessing the hazards of oil spills and recommending revisions in Federal minerals policies which would afford greater protection to the marine environment. (See ch. III.)

Activities of Other Agencies

In addition to Department of the Interior programs specifically oriented toward marine minerals development, many other departments and agencies support closely related activities. Through its Coast and Geodetic Survey, the Environmental Science Services Administration conducts bathymetric and geophysical surveys of the continental shelves and deep ocean areas. The bathymetric charts are used by both the private and public sectors as base maps upon which seafloor geology, subfloor structure, and potential mineral-bearing areas are overlaid. For this reason, the selection of geographical areas is closely coordinated with the offshore mapping programs of the Geological Survey. A long-range mapping program has been developed for the entire continental shelf of the United States with annual priorities determined to a large extent by the immediate requirements of the various users. Maps have been published recently for areas of the California and Oregon coasts, and others are being prepared for parts of the Gulf of Maine and for the sea floor off North Carolina.

ESSA is also pursuing a program of scientific exploration and mapping (SEAMAP) designed to complete the mapping of 30 percent of the world's oceans, primarily the Eastern North Pacific and most of the North Atlantic, in the 1980's. The output of this program will be 1:1,000,000-scale maps showing the bathymetry and the geophysical and geological properties of the sea floor. Last year, a bathymetric map with geophysical overlays was published for Norton Sound, Alaska. In addition, ESSA's environmental prediction services aid all Federal and non-Federal sea-based operations undertaken to understand and develop mineral resources.

The Navy conducts geophysical surveys on the U.S. continental margins as well as in the deep ocean in response to defense requirements and makes most of these data available to the public. In addition to last year's regional study of the Gulf of Mexico carried out cooperatively with the Geological Survey, the Navy is currently conducting surveys of the Eastern and Western Test Ranges off Florida and California. Evidence of saltdomes—typically shallow water structures often associated with petroleum and sulfur—was found during a joint Navy-university geophysical survey of a 15,000 square mile area off Northwest Africa in water depths up to 18,000 feet. Together with recent findings of similar structures at unexpected depths in the Gulf of Mexico, off the Grand Banks in the northwest Atlantic, and in the Medi-

terranean Sea, many new questions are raised about the history of the ocean basins and previous estimates of mineral potential of the deep oceans may have to be revised upward.

Another example of spinoff to the marine minerals area from the Navy's military-oriented program is the identification of what may be one of the most prolific oil reserves in the world on the continental shelf between the Republic of China and Japan as the result of a survey undertaken with the contract vessel R/V *F. V. Hunt*. Three small basins beneath the Yellow Sea were also found to be highly promising areas for petroleum deposits.

The Army Corps of Engineers, through its Coastal Engineering Research Center and Lake Survey District, has been conducting a sand inventory program since 1964 as part of a beach replenishment effort. To date, some 7,300 statute miles of seismic profiles and 1,000 cores have been collected, in large part under contract with private industry. A cooperative inventory program with the U.S. Geological Survey is currently underway to assess sand deposits in areas of mutual interest such as Long Island Sound.

The U.S. Coast Guard conducts oceanographic surveys off Alaska which involve geophysical measurements and bottom sediment samples. The "Polar Profile—1969" program in the Chukchi Sea, carried out jointly by the Coast Guard, the Geological Survey, and ESSA, has been previously mentioned. As the development of the mineral resources of the polar regions intensifies, Coast Guard supporting services involving the maintenance of transportation routes, logistic support for bases, and safety-at-sea will become increasingly important.

The National Science Foundation annually funds some $1.5 million in university research on the origin, evolution, structure, lithology, and sedimentology of the U.S. continental margins and the deep ocean basins. Knowledge of the sources of known mineral deposits, the distribution of sediments by waves and currents, and the formation and movement of the oceanic crust is fundamental to the efficient location and exploitation of seabed minerals.

Under the Sea Grant Program administered by the National Science Foundation, offshore oil and gas studies were conducted last year on the geochemistry of offshore petroleum and the deposition of sediments; graduate education programs developed in the area of marine minerals; inventories prepared of coastal sand and deep sea mineral deposits; and geophysical studies of the Great Lakes undertaken to assess economic potential.

The Foundation is also supporting the Deep Sea Drilling Project (ch. XI) which has not only demonstrated the feasibility of new navigational systems and drilling techniques, but is adding a wealth of valuable new information to our limited knowledge of the sediments and potential mineral provinces of the deep oceans. Although virtually all accomplishments of this project are significant to the future of the offshore mining industry, several findings related to seabed mineral occurrences are particularly noteworthy:

1. The discovery of oil and gas at unexpected depths in the Gulf of Mexico associated with intrusions of salt.

2. Identification of large amounts of iron and other metal oxide precipitates in sediments at one site.

3. Demonstration that only a very small proportion of ferromanganese nodules encountered on the seafloor continues downward into the underlying sediments.

Growing Global Interest and Capability

As the decade of the 1970's begins, intensifying worldwide interest in marine mineral resources and the availability of an increasingly sophisticated mining technology are converging to generate new and unique opportunities and challenges at both the national and international levels. While the United States leads the way in harvesting minerals from the oceans and in developing offshore mining technology, virtually every maritime nation and advanced coastal State is conducting marine minerals programs. Japan, the Soviet Union, France, the Federal Republic of Germany, and Canada have all announced long-range plans or significant new discoveries.

A 65-foot electric submersible dredge, capable of working at 100-foot depths up to three-quarters of a mile offshore, is inspected prior to operation. As the dredge crawls along on tanklike tracks, a 12-inch cutter head on the end of the boom agitates the sand which is then sucked up along with water and discharged on the beach through 12-inch pipes at a rate of 9,000 gallons per minute. Two operators ride inside a pressurized compartment supplied with air and electricity through an umbilical cord from shore. The dredge is owned by Ocean Science and Engineering, Inc.

The rising interest in marine minerals is in large part attributable to knowledge that rich resources, protected for centuries by the vagaries and depths of the oceans, are becoming accessible as new technologies extend man's reach. The Deep Sea Drilling Project, Project Tektite, the voyage of

the SS *Manhattan,* and a new generation of submersible vehicles are demonstrations of the rapid development of capabilities to explore and produce resources on and beneath the surface of the water in regions heretofore restricted from man's concerted intervention by technological limitations.

As noted earlier, exploratory drilling for oil has been extended to water depths of 1,500 feet and, within 10 years, actual production should be possible in water four times as deep. This year, as part of the second phase of the Deep Sea Drilling Project, a sonar-based system for reentering drill holes will be tested aboard the *Glomar Challenger.* Drilling at sea has been seriously hampered by the necessity of abandoning a hole once the drill bit has dulled. Successful introduction of the reentry system will not only open the way for exploratory and development drilling to great depths in the deep ocean but will allow for the placement of seismographs, heat probes, and other instrumentation beneath the sea floor. Also to be tested is a turbocoring unit in which water pressure turns the drill while the drill string remains stationary.

In response to variety of requirements, the offshore petroleum industry is beginning to move many of its operations under the sea. Last August, a 15,000-ton, 5,000,000-barrel bottomless underwater tank, 20 stories high, was installed in 158 feet of water off Dubai in the Arabian Gulf for the storage of crude oil. (See photograph at beginning of this chapter.) The system avoids the need for onshore storage tanks and underwater pipelines, and may have wide application off countries where lack of deep water port facilities prevents docking of supertankers.

Beginning this spring, a number of companies including Lockheed, North American Rockwell, and Deep Oil Technology will test prototype petroleum production systems emplaced beneath the surface of the water on the ocean floor. These systems are designed to give producers the capability to extract petroleum from multiple wells in water depths of 1,500 feet or more, with manned operations conducted under shirtsleeve conditions in an enclosed capsule. The drilling would be accomplished from surface drilling ships. Undersea location of production equipment will reduce storm and marine traffic hazards, and avoid cluttering the oceans and coastal areas with often unsightly surface structures. The President's Panel on Oil Spills, in its report "Offshore Mineral Resources," [3] recommended that the Government move in the direction of a policy that would require offshore oil and gas production structures to be totally beneath the surface of the sea in specified areas.

Technology for the recovery of unconsolidated minerals lying on the seafloor is also advancing. Last year, a submersible dredge, capable of operating up to three-quarters of a mile offshore free from unpredictable air-sea interface effects, was placed into operation by Ocean Science & Engineering, Inc., off Florida's east coast in a prototype test sponsored by the Corps of Engineers and the State of Florida. Design and testing of a variety of new concepts in airlift and suction type hydraulic dredges for deep water operations are also underway.

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[3] "Offshore Mineral Resources—A Challenge and an Opportunity"; Second Report of the President's Panel on Oil Spills; Office of Science and Technology, 1969.

This summer, a prototype mining system for manganese nodules which utilizes a unique dredge head will be tested by Deepsea Ventures, Inc. in water depths of 3,000 feet on the Blake Plateau. The same company is currently delineating possible mining sites in the Pacific Ocean as well as operating a mini-pilot plant to evaluate the economics of a chemical process for separating and recovering the manganese, copper, nickel, and cobalt. Indicative of the growing global interest in harvesting manganese nodules is the recent announcement by Japan's Transportation Ministry that a subsidy will be awarded for the construction of manganese mining ships as part of a program to develop new reserves of raw materials for its steelmaking industry.

The research ship Prospector *dredges manganese nodules from depths of 2,500 feet on the Blake Plateau off the U.S. southeast coast. More than 40 tons of nodules were obtained on this cruise for laboratory analysis and pilot plant studies.*

Major Challenges of the Seventies

In spite of the growing demand for minerals and the availability of enhanced technological capabilities for exploiting them from the oceans, two strong countercurrents have developed during the past several years which may have a retarding effect on offshore mineral production during this decade. The first of these is growing preoccupation with preserving and securing the quality of our environment. Concern over the quality of our inland lakes and rivers and the air we breathe has expanded to encompass the oceans, particularly the near-shore areas. This is largely the result of a series of highly publicized disasters and near-disasters which have included the Santa Barbara blowout and the *Torrey Canyon* and *Ocean Eagle* oil tanker spills. Much has also been written recently about possible detrimental effects of mineral dredging and processing operations at sea on the ambient environment.

Potential hazards on a previously unknown scale are being created by an ever-growing world fleet of supertankers which even today plies waters off heavily populated coastal areas and which may, in the near future, operate in the Arctic. The extremely slow degradation of oil under polar conditions due to lack of microbial action makes both the prospect of its exploitation and transport in far northern seas unpalatable to many. To anticipate and address potential problems of environmental degradation stemming from resource development in this region, the President's five-point marine sciences program includes an expansion of Arctic research, with special emphasis on ecological considerations.

Thus a major challenge in the 1970's will be the achievement of a balance between potentially conflicting objectives of marine resource development and environmental protection which will preserve the rights of the public, industry and Government while at the same time maximize net national benefits, social as well as economic. As discussed in chapter III on the coastal zone, this delicate balance must be achieved within the framework of a multiple-use concept which avoids the equally unsatisfactory extremes of complete freedom for industrial mineral development on one hand and complete exclusion of the mineral industry from coastal waters on the other.

Paradoxically, a second major challenge to an expansion of marine minerals mining is being generated by growing worldwide interest in the minerals. As described in chapter XIII on international policy, the Malta proposal in the fall of 1967 focused international attention on the questions of ownership of the seabed minerals outside the boundaries of national jurisdiction and how these boundaries are to be determined. Subsequent discussions within various international forums and individual nations have: stimulated the interest of developing coastal nations in the mineral potential of their offshore margins; raised the possibility for developing landlocked states of sharing in the economic benefits from deep ocean minerals; and created fears in many mineral exporting nations by raising the specter of a new source of competition. The net effect of this focusing of attention may actually retard the exploitation of seabed minerals in the years immediately ahead. This was demonstrated by passage of a resolution by the United Nations in December 1969, despite opposition by the United States, which

would prohibit mining activities in areas beyond limits of national jurisdiction pending creation of an international legal-administrative regime for the deep oceans.

Even within the United States, ownership of offshore mineral rights is still an issue, both at the Federal-State and State-State levels. Last year, legislation was introduced in Congress on behalf of the Atlantic Seaboard States to extend their offshore exploitation rights out to 12 miles from the present 3-mile limit established by the Submerged Lands Act of 1953. As a result of claims to undersea lands out as far as 100 miles based on colonial charters, the Government filed suit in April against 13 Atlantic Coast States (the Original Thirteen less Vermont and Connecticut, plus Maine and Florida) to bring final resolution to the question of ownership of mineral rights on the Atlantic continental shelf. Other longstanding disputes over title to minerals off U.S. coasts remain unsettled due in part to the absence of fixed and identifiable baselines in most coastal areas from which to determine jurisdictional boundaries.

The importance attached to resolving the broad questions of jurisdiction over continental shelf and deep ocean resources is manifested by the establishment of three special congressional subcommittees during 1969 and the rising attention to ocean law in academic and professional circles.

In no area of marine science are the benefits from—indeed, the necessity for—a public-private partnership more apparent than in the development of mineral resources. The exploitation of these resources will continue to be conducted by private industry. At the same time, the minerals are on public lands and must be managed in accordance with overall national priorities and objectives, including considerations of foreign policy. In view of the mineral potential of the oceans and the complex issues confronting their continued exploitation, it is imperative that the Federal and State Governments and private industry work together to develop policies which take into account the economic incentives that motivate industry to move seaward, the rapidly evolving technology for doing so, the growing public demand for adequate environmental protection, and the implications of these policies for our broader international objectives. During this decade, development of judicious and effective policies for marine minerals will take on a growing urgency—and will require the application of the best of our national talents drawn not only from science and technology but also from the disciplines of law, economics, sociology, conservation, and international affairs.

Chapter VI

ACCELERATING USE OF FOOD FROM THE SEA

The United States has an important stake in furthering development of the sea's food resources. The fishing industry can contribute to domestic and international economic development, provide employment, conduct research to assist in using the oceans more effectively, and provide food for combating hunger and malnutrition in the Nation and the world.

The world's rapidly increasing population portends an urgent need for increased supplies of food from all sources. By the year 2000—one generation from now—more than 6 billion people will be competing for the earth's food and resources. Already many developing areas of the world are critically short of animal protein.

The living resources of the sea can contribute importantly to meeting a part of the worldwide need for animal protein. The present harvest of the ocean is roughly 64 million tons annually. Seafood production is one of the few major foodstuffs increasing faster than population growth. The Food and Agriculture Organization estimates indicate that a well-managed world fishery could yield three to five times the current output. Large quantities of the unutilized living marine resources lie off our own coasts and the coasts of many protein-deficient countries. The world fish catch, major areas of resources potential, and protein deficiency are indicated in figure VI–1.

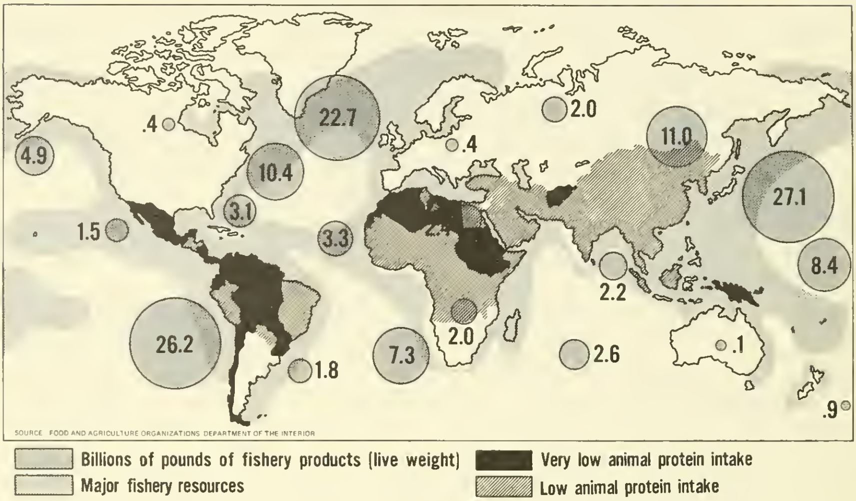
The Marine Sciences Act calls for rehabilitating our commercial fisheries, as part of a national policy for marine science. The act also states that U.S. marine science activities should be conducted so as to contribute to a variety of objectives, including accelerating marine resource development and fostering international cooperation in the national interest. One of the first initiatives taken under the act was to seek to use U.S. technology and leadership to develop food from the sea to help feed the undernourished people of the world.

The U.S. Fishing Industry

The United States has extensive coastal areas inhabited by large varieties and quantities of potentially valuable fish and shellfish. The Bureau of Commercial Fisheries estimates these areas could yield nearly 20 million tons annually, or six to seven times the current production. Yet today our fisher-

Menhaden purse seiners—members of the Nation's fishing industry—load their catch off Southport, N.C.

Figure VI–1—Fishery Catch, Resources and Areas of Protein Deficiency, 1968



men harvest but one-tenth of this potential; foreign fishermen take most of the fish caught in international waters off the U.S. coast. While world fishery production shown in figure VI–2 has sharply increased, the annual catch by U.S. fishermen has remained almost level at 2.2 million tons. Moreover, while U.S. fish consumption has trebled during the last three decades, and while today the United States provides the most lucrative world market for fishery products, only a small part of our total fish consumption is provided by domestic fishermen. In 1969, about 60 percent of the total U.S. supply of fish products came from imports. Figure VI–3 portrays the trend of the U.S. supply of fishery products. The sharp decline in U.S. fish imports last year resulted from a short supply and higher prices of fish meal for animal feed on the world market and the substitution of soybean as an alternative protein source.

The generally static condition in parts of the harvesting segment of the U.S. fish food industry contrasts with the dynamic growth of some parts of the processing and distribution segments of the industry. A few branches of the harvesting industry—such as the shrimp and tropical tuna industries—are growing, energized by technology and aggressive management developed at home and in overseas operations. U.S. processing and distribution firms have established extensive collecting networks for raw and semi-processed fishery products in more than 30 countries, primarily in the developing world.[1]

This increasing dependence on foreign sources for primary production has occurred because many bulk raw fish and fish products can be secured at a lower cost from foreign than from U.S. producers. The high costs of U.S. producers compared to foreign result from a number of factors, including

[1] The Council contract report "Multinational Investment Opportunities in Ocean Activities" describes some of these activities.

the requirement that U.S. fishing vessels be built in the United States,[2] the tangle of confused and conflicting local and State regulations,[3] relatively high

Figure VI-2—Catch of Seafoods by Leading Countries

NOTE LIVE WEIGHT BASIS
SOURCE FOOD AND AGRICULTURE ORGANIZATION, DEPARTMENT OF INTERIOR

[2] A 1793 law (46 U.S.C. 251) in effect requires that vessels over five net tons engaged in our fisheries must be built in U.S. shipyards. A 1966 subsidy law, intended to offset the high costs of construction in the United States, has not had a significant impact and at the same time reduces incentives to lower construction costs.

[3] These laws and regulations are summarized in the Council contract report "The Land-Sea Interface of the Coastal Zone of the United States."

U.S. living standards and costs, subsidized foreign production, and high vessel casualty rates.[4] However, a substantial part of high U.S. costs stems from our management of the fisheries as common property resources which often leads to over capitalization, more boats and fishermen than are needed to harvest the optimum yields, and resulting conservation regulations which downgrade harvesting efficiency to limit the total catch of the larger-than-necessary fishing fleet. This profit squeeze is widely felt, contributing to locally depressed incomes, limited and highly selective capital investments in U.S.-flag fishing vessels, and unemployment in some U.S. fishery localities.

Revitalizing the Fishing Industry

The domestic and foreign demand for fish and shellfish products will continue to mount in the years ahead, as both staples and gourmet foods. Many U.S. coastal communities and industries will continue to rely upon the fishing industry to supply jobs, income and raw materials.

Programs of research and development have an important role to play in strengthening the fishing industry. Basic biological studies provide a basis for assessing fish yields. Surveys and exploratory fishing programs establish the potential of latent fisheries. The development of new harvesting techniques, fishing gear, and equipment can increase catches and reduce costs. Better and more efficient methods for processing and handling fish products—including quality control and diversified product use—broaden the market and provide more and better fish products for the consumer.

During the past several years numerous studies have been conducted within and outside the Government to identify more clearly ways to overcome impediments to growth of the harvesting sector of the seafood industry. Of importance was a March 1968 conference of representatives of all parts of industry, partially supported by the Marine Sciences Council.[5] The Conference recommended that the Federal Government reexamine fishing restrictions that reduce efficiencies of the fisherman, consider limiting the number of fishermen exploiting stocks already being fully harvested, improve statistics on fisheries, strengthen U.S. policies concerning fishery management, and take into account food shortages on a worldwide scale in

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[4] "A Study of Cost Benefits and Effectiveness of the Merchant Marine," U.S. Coast Guard, May 1, 1968, identified fishing vessels as having the poorest safety record of any group of U.S. vessels.

[5] The Conference on the Future of the U.S. Fishing Industry was held on Mar. 25–27, 1968, at the University of Washington, Seattle. Sponsored by the university and industry as well as the Federal Government, it brought together 266 experts from the diverse segments of the fishing and fish processing industry. Proceedings of the Conference were published in "The Future of the Fishing Industry of the United States," University of Washington—Publications in Fisheries—New Series, Vol. IV, 1968.

Figure VI-3—U.S. Supply of Fishery Products

promoting development of the domestic industry. Private industry was urged to develop and expand the seafood market and to provide better education and training in the industry.

The Marine Sciences Council in 1968 considered an approach to the problems of U.S. fishermen and of developing a healthy industry, including such steps as providing uniform guidelines for fishery conservation and management, revising fishing vessel subsidy program, encouraging greater vertical integration of the U.S. fishing industry, and increasing use of technology and better fishery statistical information.[6]

In this context the Bureau of Commercial Fisheries (BCF) is considering programs and policies which could—

(1) *Reduce production costs by* providing improved resource information and reliable forecasts to cut search time for fish and improve scheduling and equipment use; developing more efficient harvesting technology; encouraging adoption of economic management systems

[6] This approach was outlined in more detail in the Council's third annual report, "Marine Science Affairs—A Year of Broadened Participation," January, 1969.

which will discourage over-capitalization and overbuilding of vessels for harvesting limited resources; and assisting the States to improve their management capabilities in the interest of more efficient harvesting operations;

(2) *Expand production opportunities by* developing harvesting and processing technology which will help bring new resources into production; providing fish protein concentrate (FPC) technology for developing a self sustaining FPC industry which will provide a market for underutilized fish; and assisting industry to develop techniques and procedures for economic aquaculture operations; and

(3) *Improve catches (and thus reduce per unit costs) by* developing techniques and means to preserve the critical estuarine areas as commercial fishery resources; and securing a preferred position for U.S. fishing vessels in international waters adjacent to U.S. coasts.

Fishery Development and Seafood Technology Programs

During 1969, the Bureau of Commercial Fisheries undertook to strengthen the domestic fishing industry through the following major activities:

International fisheries off the U.S. coast

Georges Bank Groundfish

1. Submitted convincing evidence of the seriously over-exploited condition of the haddock resource which resulted in the International Convention for Northwest Atlantic Fisheries setting drastically reduced limits on haddock catches in this area.

2. Inaugurated a program to encourage U.S. vessels to catch pollock as an alternate to the reduced catches of haddock.

3. Demonstrated the use of high-opening bottom trawls to increase the efficiency of pollock fishing.

4. Developed and distributed a report in atlas form showing the areas of historic pollock concentrations on the New England grounds.

Middle Atlantic Bight groundfish

Developed and presented evidence of overexploitation and potentially excessive fishing pressure which led to agreement from the U.S.S.R. and Poland to limit their fishing in this area.

King Crab in Southeast Bering Sea

Developed evidence of overexploitation of king crabs in this area which resulted in agreement of the U.S.S.R. and Japan to reduce their catch quotas.

Improved management of fisheries

1. Determined through an intensive tagging program that inshore northern lobsters are generally nonmigratory whereas offshore lobsters migrate considerable distances. This knowledge will facilitate inshore management.

2. Determined that the stocks of herring in the Gulf of Maine harvested exclusively by U.S. fishermen are genetically distinct from those which occur on Georges Bank harvested jointly by U.S. and foreign fishermen. The Gulf of Maine stocks therefore can be managed separately from the offshore stocks.

Distribution and abundance of resources

1. Secured information on the distribution and abundance of hake in the eastern temperate Pacific through the first United States-U.S.S.R. cooperative survey of hake spawning; BCF and Scripps Institution of Oceanography participated for the United States. Research in the central Pacific also secured information which identified von Karmen wakes, a disturbance that results in regular formation of eddies downstream from an island, as the mechanism which explains the tuna concentrations in the areas where eddies cause upwelling which brings cool enriched water to the surface and increases productivity.

2. Developed a new ichthyoplankton sampler which has been recommended for use in new international fish resource surveys off three continents.

3. Through the application of sonar technology mapped fish school abundance and school size distribution over a 200,000-square-mile area of the California current region. These studies indicate the presence of 1 million fish schools, mostly of northern anchovy.

4. Developed a remote underwater fishery assessment system (RUFAS) which was used in the scallop resource assessment.

5. Continued to survey the calico scallop resource off the east coast of Florida and assist in developing this fishery.

Assistance to the fishing industry

1. Devised a new chemical process for recovering additional marketable byproducts from shellfish processing waste.

2. Increased the oyster shucking rate by use of microwave energy to assist in opening the shell, without affecting the quality of the product.

3. Cooperated with the industry in developing a fast-sinking purse seine for tuna which gives increased catch rates over conventional seines.

4. Promoted the expansion of domestic and foreign markets for Alaskan fishery products.

5. Conducted research on diseases of marine organisms to help develop control measures which (1) identified a new protozoan pathogen in blue crabs; (2) led to a screening program to insure importation of healthy seed oysters from the Orient; and (3) worked out the life cycle on the MSX organism, *Minchinia nelsoni,* an oyster destroying parasite.

The Bureau of Commercial Fisheries is conducting experimental work in aquaculture at several of its laboratories. The application of aquaculture techniques for rearing some types of aquatic animals under controlled conditions has produced large per acre protein yields. To realize the potential of aquaculture requires advancing scientific knowledge and developing technology to permit production at competitive costs. BCF is conducting re-

search on oyster culture techniques, selective breeding, nutrition and diseases; on shrimp pond raising and nutrition; and on hatchery raising of lobsters, including their growth and its requirements.

In addition to its marine science programs, the Bureau of Commercial Fisheries administers three grant-in-aid programs to States. The State grant-in-aid programs are intended for research and development which will provide the basis for more effective management of fishery resources.

The Bureau also provides data and technical support for significant international fisheries programs in which the United States participates. Details of these programs are discussed in chapter XIII.

The Bureau of Commercial Fisheries $46.8 million FY 1971 marine science budget is allotted as follows—

(1) 55 percent for resource development and management programs;
(2) 8 percent for processing and marketing programs;
(3) 11 percent for advanced technology programs;
(4) 2 percent for economic research programs;
(5) 23 percent for financial assistance and grant-in-aid programs; and
(6) 1 percent for data and technical support for international fisheries programs.

Collateral Support by Other Agencies

The Atomic Energy Commission supports advanced investigations related to the presence of radio nuclides from atmospheric fallout in the ocean, their interactions with organisms, and the use of tracers in oceanic research. The AEC also is supporting publication of a book on bioenvironmental studies of the Columbia River Estuary and the adjacent ocean region.

The Food and Drug Administration's responsibility has been broadened under the shellfish sanitation program, a Federal-State-industry program designed to insure safe consumption of shellfish such as clams, oysters and mussels, shipped in interstate commerce. The program includes surveying water quality, evaluating sanitation facilities of packers and shippers, and reviewing State control programs. The FDA also is undertaking research on botulism in fishery products, canned salmon standards of identity and quality, nitrites in smoked fish, and toxins from fish. The Department of Health, Education, and Welfare's Environmental Control Administration conducts studies of the course of viral pollutants in estuaries, their accumulation by shellfish, and purification process effectiveness in removing these viruses from shellfish.

During 1969, the administration proposed a bill to strengthen and improve consumer protection under the Federal Food, Drug, and Cosmetic Act with respect to fish and fishery products through mandatory certification coupled with continuous, effective surveillance and continuous inspection.

The Department of Agriculture's Soil Conservation Service provides technical assistance to farmers and ranchers in soil conservation districts to help

in developing aquaculture, primarily of catfish and to some extent of trout. The program seeks to assist in conserving and developing water resources by using the resources for food and recreation.

The Smithsonian Institution provides essential, fundamental information on the kinds of fishery organisms being sampled, produces monographs and guides to the identity of harvested organisms and those serving as food for commercial species, provides information on the populations and distribution of species which might have commercial importance or which are parasites and predators on useful species, and provides a sorting service for bulk samples of marine species.

The National Science Foundation furnishes basic scientific research support in biological oceanography and marine biology for investigations related to marine organisms. Through the Sea Grant Program it supports graduate, undergraduate and institutional investigations on aquaculture, fisheries and drugs and extracts from the sea—related in greater detail in chapter VII.

The Coast Guard participates in enforcement of international fishery arrangements. The Navy makes its fleet thermal structure forecasts, gathered to determine underwater sound propagation, available to BCF for fish location forecasts. Sea-life distribution is affected by water temperature, and the Navy thermal profiles, provided at no cost to BCF through a cooperative arrangement, have proved useful to fishermen in locating fish. In addition to meeting national security objectives the Navy's marine biology research program also contributes to information on seafood.

Food From the Sea in the War on Hunger

Recognizing that food from the sea offers considerable promise in meeting a portion of the world's protein deficiency, the United States embarked in 1967 on a new food-from-the-sea program with the Agency for International Development (AID) assuming lead agency responsibility. The Marine Sciences Council gave high priority to the program, the initial objectives of which included development of commercial processing for producing fish protein concentrate (FPC). The program is intended to—

(1) Determine the potential market for FPC in selected developing countries;

(2) Seek to establish a viable commercial FPC system suitable for use in protein-deficient developing countries; and

(3) Encourage other nations and private interests to establish commercial fishing industries in the developing countries.

During 1969 the Marine Sciences Council acted to insure a long-term basis for the program by supporting AID's initiatives to continue acceptability testing and analysis of the feasibility for use of various available FPC production processes in less developed countries, and strengthening the base of university technical support in the United States and abroad. It also encouraged BCF efforts to develop a prototype process for fatty fish, construct an FPC

demonstration plant in the State of Washington, and carry out biological extraction research. Public Law 90–549 authorized the contract for design, construction and operation of a 50-ton-per-day plant at Aberdeen, Wash., to demonstrate the feasibility of large-scale FPC processes at lower costs and to provide engineering and economic data to assist private industry in construction of commercial plants. The Council also approved initiatives for a multiagency effort to investigate the potential of FPC in combatting malnutrition in the United States within the framework of the broad program announced by the President in May 1969 (see table VI–1).

Also during the year the Council contracted with the Massachusetts Institute of Technology for a study of "The Economics of Fish Protein Concentrate" which would compare FPC with other protein additives for domestic and foreign use.

The Agency for International Development conducted preliminary surveys of the opportunities for developing FPC capabilities in a number of Latin American, Asian, and African nations. As a result of these surveys, intensive studies were initiated on a bilateral basis in Chile and Korea in 1968, and a study of Morocco is expected to begin in mid-1970. The emphasis of the Korean study was altered when it became apparent that Korea lacked an inexpensive source of fish for economical FPC production. Although construction of an FPC plant in Korea is not now contemplated, the study showed that FPC was the best source of protein there from a cost-protein-effectiveness viewpoint.

The Chilean study will continue through fiscal year 1970, and will assist potential investors in determining the commercial attractiveness of FPC investment in that country. The Chilean study includes—

(1) Market analysis, including identification of factors contributing to dietary patterns, determination of opportunities for encouraging consumer acceptability of FPC, and introduction of FPC into Government feeding programs;

(2) Product development and testing to determine the suitability of FPC in fortifying local foods such as flour, bread, and pasta; and

(3) Supply analysis to determine availability of an adequate supply of inexpensive underutilized fish stocks.

In 1968 AID contracted to purchase approximately 1,000 tons of FPC for use in overseas feeding programs. In late 1969 AID partially terminated the contract for failure to deliver an acceptable product.

AID has accepted delivery of 99 tons of FPC and will accept FPC produced before the contract was terminated provided the product meets contract specifications. The limited quantity obtained will be allocated so as to obtain data on product development, acceptance, and stability. An interdisciplinary team from the University of California is assisting AID in this evaluation. Future FPC purchases will depend upon the findings of this evaluation and the ability of the manufacturer to produce acceptable FPC.

Table VI-1—Food From the Sea in the War on Hunger

[Obligations in thousands of dollars]

	Actual FY 1969	Estimated FY 1970
Bureau of Commercial Fisheries (BCF):		
Research and development	2, 242	2, 292
Demonstration plant	312	1, 388
BCF subtotal	2, 554	3, 680
Agency for International Development (AID):		
FPC purchase and implementation	72	52
Pilot plants	0	8
FPC market feasibility study	0	241
Subtotal FPC	72	301
Fishery surveys	10	4
Center of competence	750	0
Direct fish production	704	704
General technical assistance [1]	704	704
Fish culture	293	0
Subtotal, other items	2, 317	1, 615
AID subtotal	2, 389	1, 916
Total food from sea	4, 943	5, 596

[1] Mostly United Nations Development Program.

Under an AID program to further the development of university expertise in the economics of international fisheries, a fisheries "center of competence" has been instituted at the University of Rhode Island. AID has granted $750,000 over a 5-year period to assist that university in undertaking an inter-disciplinary curricula for both U.S. and foreign students to focus upon the development of world fisheries, with particular emphasis on the socioeconomics of fisheries development.

In fiscal year 1971 AID plans fishery programs in the amount of $2.6 million.

In developing FPC technology during 1969, the following accomplishments highlighted the program. The Bureau of Commercial Fisheries—

(1) Completed predesign research, process, and plant design, and commenced site preparation for a 50-ton-per-day FPC demonstration plant at Aberdeen Wash., described above. In fiscal year 1971, the plant is expected to be completed. It will commence experimental production using Pacific hake;

(2) Prepared samples of FPC from a number of species of lean and fatty fish to obtain information needed for process modification, and to provide sample material for testing and nutritional evaluation;

Through the application of science and technology, fishing vessels are equipped with the latest processing equipment. The 297-foot, 3,120-ton freezer stern trawler Seafreeze Atlantic, *shown above, like its sister ship* Seafreeze Pacific, *was built with U.S. Government assistance. They are among the largest fishing vessels constructed for operation under the U.S. flag.*

(3) Submitted a petition to the Food and Drug Administration to increase the variety of fish species which may be used for making FPC. The petition covers most species off U.S. coasts which are suitable for making FPC;

(4) Completed governmental and nongovernmental studies which provided the design basis for a distillation system for economical recovery of the solvent (isopropyl alcohol) used in the FPC extraction process;

(5) Commenced study of systems for making FPC by different processes such as through biological extraction which will lower processing cost and provide valuable functional properties to increase the product's range of application; and

(6) Initiated contract studies to estimate capital and operating costs for various FPC processes and the potential markets in the United States for different forms of FPC.

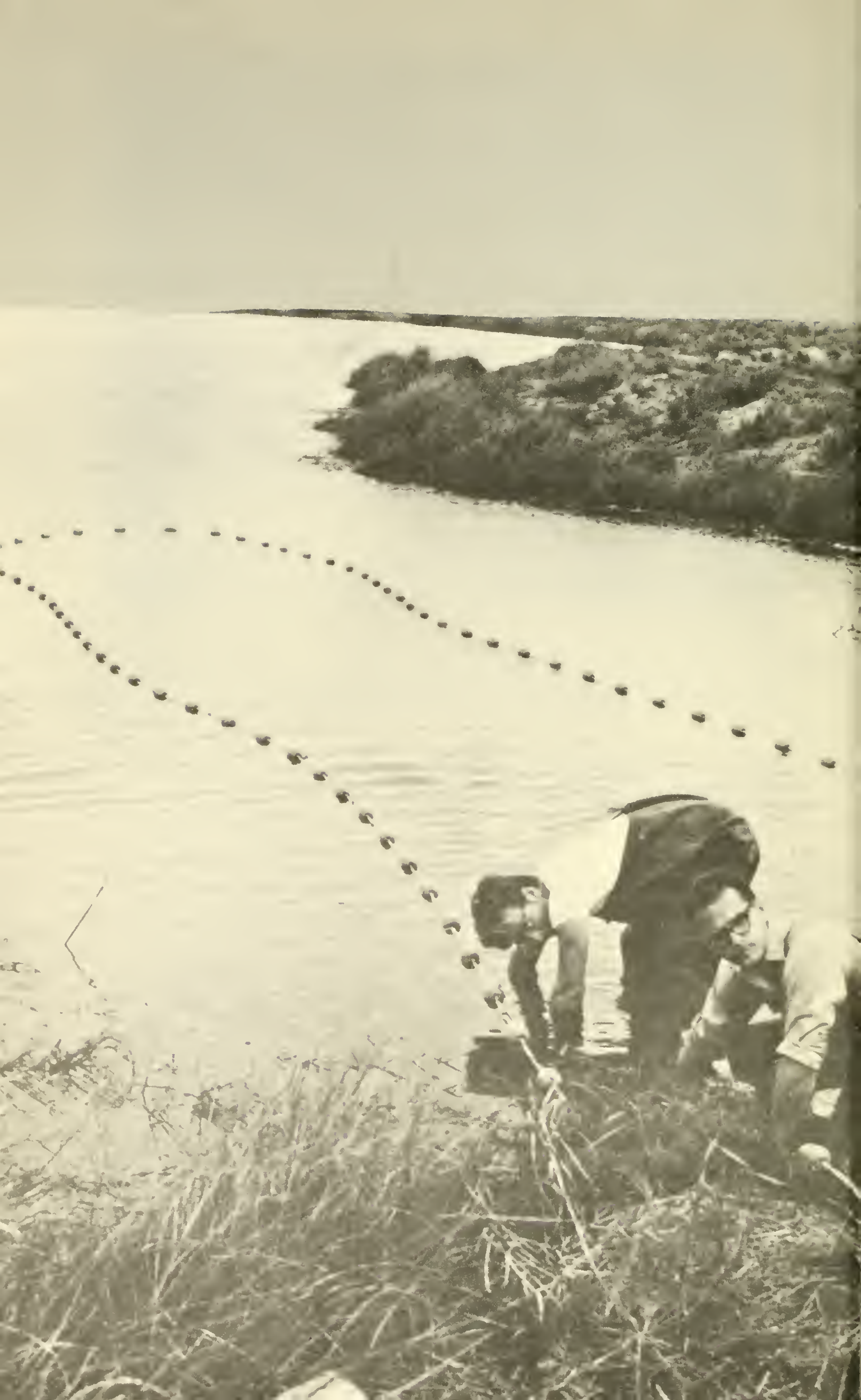
To supply industry with information on practicable FPC manufacturing methods which could use a large portion of our unused marine resources, the Bureau of Commercial Fisheries will continue FPC research involving approximately $2.2 million in fiscal year 1971. The program will continue to seek to provide knowledge for a sound and systematic transition from

laboratory research to an economical and acceptable food production system from fish harvest to consumption.

International interest in FPC processing is developing. Processing plants are operating in Sweden and planned for Canada. The French are developing an enzyme process, and research FPC activities are being conducted in Brazil, Germany, Morocco, Pakistan, and Peru. During 1969, Swedish and U.S. sources sent FPC to Nigeria as a food additive in small scale experimental feeding programs.

The Industry's Future

A healthy fishing industry can make a contribution to the economy and to providing needed food resources. Attaining a competitive fishing industry will require a multiple attack on the industry's problems involving scientific research to improve understanding of the resources, exploration to ascertain quantities and location, technology for better harvesting and processing, uniform State, Federal and international guidelines for conservation and management, improved marketing, and better management practices by the industry itself.



Chapter VII

ADVANCING THE SEA GRANT PROGRAM[1]

During the coming decade, our ability to develop marine resources and wisely manage the marine environment will depend upon the availability of trained manpower, facilities, and equipment to conduct programs of creative research in the fields of marine science, engineering, and related disciplines. With a view to meeting these requirements, the Congress in October of 1966 passed Public Law 89–688, the National Sea Grant College and Program Act of 1966 (app. B–3). It was the intent of the Act to provide a broad and flexible mechanism with which to stimulate human endeavors in fields oriented toward: development and utilization of the physical, chemical, and biological resources of the marine environment; legal, economic, medical, and sociological aspects of resource management, use, and conservation; oceanography in its broadest sense; and marine commerce and engineering.

Statutory responsibility for administering the Sea Grant Program was given to the National Science Foundation and included (1) establishment of educational and training programs at colleges and universities, marine institutes and other public and private agencies in the various fields of marine resource development; (2) initiation and support of research programs in those fields, with particular emphasis on applied research; and (3) encouragement and sponsorship of marine-oriented extension and advisory services.

The Structure of the Program

Provisions of the enabling legislation, which calls for Federal support of both "Sea Grant colleges" and "Sea Grant programs," have resulted in the establishment by the National Science Foundation of two major operational program elements: the "Institutional support program" and the "Project support program."

Sea Grant *institutional* support is provided to institutions which plan and operate broad-based, multidisciplinary marine resources programs that include research, education, and advisory services—and which draw on the talents of economists, sociologists, political scientists, lawyers and educators as well as natural scientists and engineers. The institutions selected are expected to develop strong liaison with State and local governments and thereby provide leadership and scientific and technological resources for marine activities within their regions.

Sea Grant *project* support is available to qualified investigators for a single, well-defined research, study, design, education, advisory service, or training activity consistent with board Sea Grant objectives, and which in-

[1] This chapter is in compliance with Public Law 89–688, sec. 205, which requires an annual report to the Congress by the Marine Sciences Council on its advisory activities and recommendations, as assigned under that section, with respect to Sea Grant policies, procedures, and operations.

Under the Texas A&M Sea Grant, university scientists investigate the cultivation of shrimp under controlled environmental conditions.

volves any of the natural or social sciences. While only major universities or combinations of universities qualify for institutional support under the Foundation's criteria, any institution, laboratory, or public or private agency may qualify for project support. The principal purpose of Sea Grant project support is to enlist specific competence wherever it is found, in inland institutions as well as in those with access to salt water or the Great Lakes.

A third program, the *coherent project* support program, is a middle-ground hybrid of the other two. It is multidisciplinary in scope, composed of several subprojects directed to a common objective or related to a common theme, and provides means for (1) encouraging institutions with a strong core of marine competence and growth potential to work toward Sea Grant institutional status; and (2) bringing into the Sea Grant Program institutions with high quality but specialized competence which do not meet the criteria for institutional support. In the case of all three programs, Federal support is limited to two-thirds of the total cost, and certain restrictions, especially on capital investment for ships and laboratories, are imposed.

Program Planning and Policy Development

To implement the Sea Grant Act at the working level, the National Science Foundation created an Office of Sea Grant Programs. Assisting this Office are two nongovernmental, technical advisory panels. Some 50 specialists, representing a cross section of marine interests and institutions, participate in a Proposal Review Panel for Sea Grant Projects operating through task teams which review individual proposals. In addition, 12 eminent representatives from academia and industry serve on the Sea Grant Institutional Support Panel and, by virtue of their broad competence, are called upon to provide general program guidance to the Foundation.

Maximizing opportunities and benefits from a program as broad and as flexible as Sea Grant requires that it be sensitive and continually attuned to evolving national needs. This, in turn, requires the existence of explicit policies and operating guidelines for implementing and conducting the program. The Sea Grant Act provides for this by directing the Marine Sciences Council to advise the Foundation with respect to program policies and operations—and, further, to submit an annual status report to the Congress. Under procedures agreed to by the Foundation and Council, policy statements and position papers are developed by the NSF and transmitted to the Council for review, advice and comment. The Council's consultant panels and its Committee for Policy Review act as reviewing bodies, with the latter also serving as a mechanism for obtaining formal departmental and agency concurrences and advice. After agreement is reached between the Council and the Foundation, the final step before implementation is to solicit the approval of the NSF's National Science Board.

Since the beginning of the program, a number of provisional policies and general guidelines have been developed under this arrangement and published in documents prepared both by the Foundation [1] and the Council.[2]

[1] National Sea Grant Program—Suggestions for Submission of Proposals; National Science Foundation, September 1967.

[2] First, second and third annual reports, prepared by the Marine Sciences Council and transmitted by the President to Congress, on "Marine Science Affairs," February 1967, March 1968 and January 1969.

These cover, among others, criteria for determining institutional and project awards including geographic distribution and cost-sharing responsibilities of the grantees; program priorities; and the roles of industry and State and local governments.

On the basis of 2 years of operating experience, the National Science Foundation staff has been able to evaluate the Sea Grant Program's provisional policies and develop a coherent body of doctrine which was endorsed last November by the Marine Sciences Council's Committee for Policy Review. Elements of this include the following:

1. Support under the institutional and coherent project programs requires institutions to utilize a multidisciplinary approach in the conduct of funded activities which involve all appropriate disciplines and specialties.
2. All Sea Grantees will be encouraged and aided to enlist the cooperation of all relevant institutions in the conduct of supported activities including business and industry, other educational or research institutions, Federal laboratories and offices, and State and local agencies.
3. High priority will be given to support of research, education, and advisory services in areas of national priority as established by the Marine Sciences Council, with particular emphasis at this time on problems and opportunities of the coastal zone.
4. Participation by consortia of institutions will be encouraged where such consortia can make a greater contribution to Sea Grant objectives than a single institution in the same geographical area.
5. As a general rule, low priority will be assigned to research projects in marine resource fields where adequate coverage and financing from other sources exist (e.g., natural gas and petroleum exploration and recovery).
6. With respect to education and training programs, Sea Grant emphasis will be placed on curriculum and course improvement and development for ocean engineers at the baccalaureate and graduate levels; on development of degree programs and course options in marine affairs for social scientists, lawyers, business administrators and managers at the graduate level; and on curriculum improvement and course development at the technician level.
7. The Sea Grant Program will not support educational curriculum or course development in the basic natural or social sciences.
8. Education or training activities will not be supported in a given institution after they are self-sustaining or are included in the regular budget.
9. Basic research will be supported in areas where such research is a requirement for the solution of a defined and pressing problem and where early application of results seems likely; research by social scientists will be encouraged.
10. "Open-ended" studies will not be funded; studies must be programed with milestones and terminal dates.
11. Involvement of industry will be encouraged, particularly through the development of industry-university consortia and joint work/study programs for engineering and technician students.
12. Support for advisory services, including publications, seminars, conferences, extension services, audio/visual presentations, and any other appro-

priate form of information dissemination is included within both institutional and project grants.

13. Criteria for support of baccalaureate ocean engineering and marine technician associate degree programs include the ability of the proposing institution to demonstrate a reasonable expectancy of placing qualified graduates in jobs through correspondence with potential employers.

14. In a given fiscal year, funding preference will be accorded ongoing institutional and coherent project grants when evaluated against new proposals of approximately equal value.

15. Cooperative research projects between American institutions and those in a neighboring country related to common resources, common waters, or common problems can qualify for Sea Grant support.

Program Growth and Accomplishments

Sea Grant funding has grown steadily from $5 million in fiscal year 1968, the first full year of operation, to $9.6 million in fiscal year 1970; and the President's budget request for the coming year includes $13 million. During the last fiscal year, $5,991,000 was awarded by the Foundation as shown in the following table:

Table VII-1—NSF Sea Grant Program Awards, Fiscal Year 1969

Category of grant	Number	Amount
Institutional support [1]	7	$4, 327, 100
Project support:		
Coherent projects [2]	5	878, 500
Education and training	5	361, 600
Applied research	6	377, 000
Planning	5	46, 800
Total	28	5, 991, 000

[1] Includes 5 renewals.
[2] Multidisciplinary projects; includes 2 renewals.

To date, the Office of Sea Grant Programs has supported 57 project grants and eight institutional programs. A compilation of activities underway as of September 1969 is presented in appendix E. Sea Grant institutional support programs were begun in fiscal year 1968 at the Universities of Washington, Rhode Island, Hawaii, Wisconsin, Oregon State and Texas A&M; these were joined in fiscal year 1969 by programs at the Universities of Michigan and Miami. Coherent project support is being received by Humboldt State College, Scripps Institution, Stevenson Institution, University of Delaware, Louisiana State University, and the Virginia Institute of Marine Sciences. In addition, planning grants to assist in developing the capabilities necessary to qualify for institutional support have been made to a consortium of institutions in North Carolina and to Florida State University.

Practical benefits from research are normally not expected for some years after program initiation, and this is of course true for Sea Grant-sponsored work. However, several of the activities funded to date have already produced results which hold promise of an early return on investment:

1. In early 1968, investigators at Nicholls State College, Louisiana, attempted management of shrimp stocks in marsh impoundments. One of two ponds was used in its natural state. In the second, most predators were destroyed before introduction of the shrimp larvae, while blue crabs—a marketable predator—were trapped during the shrimp growth period. The managed pond ultimately produced about three times the weight of shrimp produced in the unmanaged pond, thereby demonstrating a promising technique for increasing the offshore shrimp fishery and for shrimp aquaculture. A commercial firm already is taking advantage of this research.

2. Building on earlier studies, investigators at the University of Wisconsin located deposits of manganese pellets in Green Bay which are similar to deep sea manganese nodules. This discovery may have economic significance, and research on the abundance, metal content, and refining of the pellets is in progress.

3. The Hawaiian tuna fishery, which still uses traditional methods of chumming with live bait, has suffered because the bait fish—a species of anchovy—cannot survive for more than 3 days in ship bait wells. However, the University of Hawaii's Institute of Marine Biology has now developed methods of extending the storage life of bait fish up to 10 days, and is experimenting with other local species in an attempt to find a hardier alternative bait.

4. With available land stocks of sand and gravel being depleted or made inaccessible by construction and zoning, the seas and lakes are being turned to increasingly as a primary source of aggregate materials. University of Rochester scientists have located such deposits in Lake Ontario and commercial firms have applied for recovery permits.

The Sea Grant institutional support program, based on a multi-disciplinary team approach to problem solving, made substantial gains during 1969. At the University of Washington, economists, political scientists, and lawyers are cooperating with physical, chemical, and biological oceanographers in a comprehensive study of all major aspects of an embayment within Puget Sound to determine how it may best be developed for human use while maintaining the quality of the environment and its living resources. Texas A&M University has begun a series of workshops to stimulate industrial, academic, and State activity in marine resource development. Members of the Governor's staff have joined as cosponsors. Attendance has been excellent, and the discussions spirited and practical.

Education and training continue to be advanced by Sea Grant institutional programs. At the graduate level, most Sea Grant institutions developed new courses to expand the marine-related options available to students, including those majoring in the liberal arts and social sciences. The University of Rhode Island instituted the Nation's first graduate program in marine affairs specifically designed for cross-disciplinary orientation of social scientists, international specialists, and administrators. Five schools developed a unified training plan for marine technicians under the University of Washington Sea Grant, with each specializing in the training of a particular type of marine technician. Texas A&M University, Oregon State, and the University of Miami have also initiated cooperative marine technician training pro-

Marine extension agents from Oregon State University discuss an albacore bulletin with a tuna fisherman as part of Albacore Central, a project conducted with Sea Grant Institution support to gather and disseminate information to assist the Pacific albacore tuna fleet identify rich fishing grounds.

grams with 2-year technical institutions and junior and community colleges participating as partners.

In addition, advisory services to communicate results of scientific and engineering research to prospective users have been expanded. In most instances it has first proved necessary to institute training programs for extension agents before beginning information dissemination. However, Oregon State University, building on an existing agricultural extension service, was able almost immediately to carry out comprehensive marine advisory activities. At the University of Rhode Island, the regional marine informa-

tion service was reorganized as the New England Marine Resources Information Program which now is operating to encourage and strengthen marine activities and industries in a six-State region. Under the Texas A&M Sea Grant, university extension advisory specialists are assisting shrimp fisherman by conducting courses to demonstrate new methods and technology such as the use of electric trawls.

Sea Grant project support activities in fiscal year 1969 included the addition of a new education program in ocean engineering and four programs to train technicians. Engineers at the Massachusetts Institute of Technology developed course materials in ocean engineering, resulting in a series of published notes on such subjects as ocean engineering structures; stability and motion control of ocean vehicles; and water, air, and interface vehicles. At Florida Atlantic University, undergraduates in ocean engineering alternated 6 months of academic work with 6 months of employment by cooperating ocean industries. Students at Cape Fear Technical Institute working aboard the institute's training ship participated in Project BOMEX. Among the individual Sea Grant projects sponsored last year were the determination of the fishery potential of the California spiny lobster; economic feasibility of a submerged buoyant pipeline for transporting natural gas through a deep ocean area; design of a high efficiency convective heat transfer system for deep submergence applications; and management and utilization of estuarine resources.

Awards of coherent project support were granted to the Virginia Institute of Marine Science, the University of California at Santa Barbara, and Humboldt State College, California, for broadly based research programs related to marine problems in their regions. Other grants were made to the Dade County, Fla., Board of Public Instruction and the Washington Technical Institute for development of educational and training opportunities for underprivileged youths.

The Next Few Years

Looking to the near future, plans for Sea Grant include strengthening existing mechanisms for the selection and review of projects and institutions, expanding the number of awards, and improving the dissemination of information about Sea Grant policies and activities. In addition, consideration will be given to establishing new graduate education programs for ocean engineers and, on an experimental basis, for business administration and international affairs specialists to acquaint them with issues and opportunities in marine-related fields.

ESSA and NSF will continue to assess the feasibility of establishing a coordinated program of data and information services, comparable to ESSA's State Climatologist Program, in order to maximize the effectiveness and utility of Sea Grant advisory activities. To test this concept, ESSA has placed an oceanographer-meteorologist at the University of Rhode Island to encourage the application of environmental data on sea-air interaction.

Through its accomplishments to date and those foreseen in the coming years, the Sea Grant Program is rapidly becoming the cornerstone of a vigorous partnership of Government and the private sector which is mobilizing new resources, techniques, and talent in support of national marine science objectives.

Chapter VIII

ADVANCING MAN-IN-THE-SEA

New advances in undersea technology, engineering and biomedicine continue to expand the third dimension of man's activities in the ocean. Where in the past our knowledge of the seas was limited to surface-based observations, today we are taking steps to develop knowledge, technology, and equipment to enable man to live and work usefully on the ocean floor for extended periods. These advances result from new developments in saturation diving and manned bottom habitats which free the diver from the restrictions of diving helmets, diving bells, and air compressors and allow him to live and work below the surface unrestricted by surface weather effects and the physiological problems of pressure change. Because these developments open new opportunities for use of the ocean, Government, industry and universities are seeking individually and in concert to advance U.S. man-in-the-sea programs.

With new technology and automation why is man needed at all undersea? The answer lies in the benefits his presence provides: advantages in his maneuverability, compactness, agility, and flexibility; in his manipulative skills and dexterity, visual perception, onsite observation; and chiefly, in his integrative and decision-making ability. The fact that these advantages constitute real benefits in part accounts for the rapid and continuing expansion of diving today.

Mounting Interest and Activity

Each year increasing public and private investment is devoted to manned diving operations, with the present total figure estimated at approximately $486 million annually. Estimated current annual U.S. expenditures in July 1969 on man-in-the-sea are contained in table VIII–1. The Nation's industry is increasingly using diving operations, particularly the oil industry which employs divers to install, monitor, maintain, and repair offshore oil installations. Other commercial diving operations include conservation, construction, salvage and safety. Man-in-the-sea observations contribute to fish habit investigation programs, study and control of fishing gear, and the development of new fishing concepts.

A number of commercial firms have significant interests in diving. A recent survey of some of the leading U.S. firms with significant investments in diving identified 12 diving companies, 24 diving equipment supply services, four recreational diving concerns, five diving equipment fabrica-

Man is increasing his capabilities to live and work beneath the ocean's surface; here an aquanaut checks grid markers outside the Tektite I habitat.

tors, 26 marketing firms for diving instruments and hardware and eight diving consultant firms.

The total number of commercial divers in the United States, including those who work part time was estimated in 1968 to be about 1,500, divided as indicated in table VIII–2.

Table VIII–1—Estimates of Current Total Annual U.S. Expenditures on Man-in-the-Sea

[In millions of dollars]

1. Science (less than)	0.5
2. Defense:	
Diving training	4.5
Diver equipment	6.8
Man-in-the-sea	7.1
Diving operations (approximately)	25.0
3. Commercial (approximately)	45.0
4. Recreation:	
Personal expenditures [1]	350.0
Diving equipment	22.5
Auxiliary equipment	25.0
Total (approximate)	486.4

[1] Estimated on the basis of 1.5 million divers, 10 dives each year, at cost of between $20 and $25 per dive.

Source: Derived from staff research, National Council on Marine Resources and Engineering Development, July 1969.

In minerals exploitation, divers make possible visual survey, maintenance and repair, evaluation of deposits, placement of drills and cores and inspection of underwater construction. In the near future it is anticipated that they will help to monitor, control and correct beach erosion and pollution—observing solid accumulations, determining emplaced structure effectiveness and operating dredges. They will assist underwater construction, tunneling, harbor development, installation of sewer outfalls, and aids to navigation. They will permit greater recovery in salvage activities and disasters at sea.

Table VIII–2—Commercial Divers in the United States

Location	Number
East coast	150
Florida	100
Louisiana-Texas [1]	1,000
California [1]	250
Alaska	60
Total	1,560

[1] Peak season in summer.

Source: Panel of Experts, 1968, National Council on Marine Resources and Engineering Development.

Man-in-the-sea techniques open new doors to the scientist. With aqualungs and long-duration submerged laboratories equipped with lockout submersibles he can make onsite observations of marine ecology, surveys for geological maps, aquaculture, archeology, studies of human adaptability and a wide range of specific scientific investigations in marine biology. At

Recreational diving is fast becoming a major marine activity. Approximately 2 million scuba divers are active, with between 50,000 and 100,000 new divers beginning each year; efforts to provide adequate diver safety standards are increasingly important.

Scripps Institution of Oceanography alone, there are more than 100 qualified divers carrying out 4,000 to 5,000 dives each year.

Recreational diving is increasing rapidly. About 2 million active scuba divers in the United States invest $40 to $50 million annually in equipment and considerably more in the sport itself. Each year between 50,000 and 100,000 people begin scuba diving. There are 1,800 diving clubs and national societies in the Nation with an average of 20 active members per club. The great majority of recreational scuba divers are not affiliated with clubs.

Growing interest and activity in the private sector of the United States has been reflected in programs of Federal agencies. The Department of the Interior has a growing need for man-in-the-sea capabilities for fisheries research, marine geology studies, environmental quality and pollution control investigations and recreation. The Coast Guard has an increasingly important role to play in its marine safety program and search and rescue activities. The National Aeronautics and Space Administration is interested in learning about group behavior and effectiveness in small habitats and hostile environments. The Department of Health, Education, and Welfare has interest in the biomedical aspects of underseas activities from both research and clinical viewpoints.

Defense requirements for diving systems capability have increased. They involve submarine rescue, salvage and object recovery, Continental Shelf construction programs, amphibious and mine warfare and harbor defense. The total number of trained divers in the Navy is about 3,000; more are needed. Navy programs related to man-in-the-sea activities are discussed additionally in chapter XII.

Increased diving activity and interest has not been confined to the United States. One of the most active and advanced programs is that of France. Now incorporated into the operations of France's National Center for the Exploitation of the Oceans (CNEXO), the French program calls for con-

struction of large hyperbaric chamber facilities for research, development and training, and use by Government, university and industry. The successful French series of Conshelf experiments has placed aquanauts at a depth of 330 feet for 21 days; these experiments are continuing and a mobile habitat is under construction.

The Soviet manned-diver habitat program began in 1965; to date some seven structures have been placed in shallow water. The German Government experimented with a new bottom habitat to conduct biological studies last summer off the island of Heligoland in the North Sea. The British and Germans are constructing shallow water habitats; the Canadians have begun tests in a habitat at 50 feet in Lake Erie, and the Czechs, Bulgarians, Poles, East Germans and Cubans have all experimented with modest habitats in shallow water.

Developing Advanced Diving Techniques

Advances in diving techniques over the past two decades have freed divers from the restrictions of tethers and have increased working depths. This is largely the result of the self-contained underwater breathing apparatus (scuba) and the use of helium and oxygen breathing atmospheres. Advances in saturation diving and employment of habitats provide a pressurized atmosphere at working depths. And, hatch access to and from the habitat permits divers to live and work in comparative comfort and safety without the need for repeated decompressions.

One of these techniques is the development of submersibles with lockout capabilities which permit delivery of a diver to a site of interest where he can sortie into the ocean environment when and if desired. At present three commercial submersibles possess lockout capability—the *Deep Diver,* the *Roughneck,* and the *Shelf Diver.* The submersible *Ben Franklin,* which this year completed a 1,500-mile Gulf Stream drift, described in chapter IX, will receive lockout modifications.

Another technique being used to provide extended work time at depth involves the use of saturated diving techniques, but without the supporting facility of an underwater habitat. In this operation, divers remain pressurized to their working depths for long periods and decompress only after completing multiple-dive objectives. They are raised and lowered from the surface in a pressurized personnel transfer capsule, and while on the surface are housed in a compression chamber at working depth pressure. Commercial systems exist, for example, such as that used by industry for successful oil rig salvage in the Gulf of Mexico. By 1972, the Navy will have three systems in use.

The advanced diving techniques were envisaged by the Navy in 1957, and incorporated in a formal program under the title "Man in the Sea" in 1961. The program has included two Sealab experiments which placed two habitats at 200 feet, with aquanauts living for about 2 weeks at ambient pressure. Presently, Sealab III is designed to extend the capability to 850 feet. Structured in four phases, the program will use a habitat in one phase to continue development of deep submergence capabilities to meet defense needs.

Projects Tektite I and II

While one Sealab diver remained underwater for 45 days, the Nation's longest duration man-in-the-sea experiment was Project Tektite I. A joint project, Tektite was managed by the Navy with Department of the Interior, NASA and industrial support at a cost of $4.5 million. Tektite I placed four Department of the Interior marine scientists on the ocean bottom at a depth of 50 feet for a record-breaking 60-day period. The project took place at Lameshur Bay, off St. John Island, in the Virgin Islands National Park during February, March, and April 1969.

The white Tektite habitat consists of two cylindrical steel tanks 18 feet high containing two rooms each. The tanks are connected by a crawl-way and mounted on a rectangular base structure which is anchored to the ocean floor. An umbilical connection of hoses and cables for fresh water, air, electric power, and communications links the habitat to a surface-support barge.

The project's major objective was to demonstrate the ability of scientists to perform research under saturation diving conditions for extended periods. This objective was achieved and the resulting data on man's behavior, efficiency, and biomedical responses in confined and isolated conditions will be useful for continuing experiments in man-in-the-sea. Tektite I proved that man can remain in good physical and physiological health working for prolonged periods underwater.

It also demonstrated the value of studying the ocean environment while living in it. The Tektite scientists conducted a variety of observations and experiments on reef geology and marine life. The bottom sediment studies may assist in the search for oceanic minerals. Investigations of lobster ecology, plankton studies and other biological studies may prove important to fish farming and aquaculture. A research project was undertaken on the spiny lobster, whose population has declined recently.

Aquanaut Crew Chief Richard A. Waller emerges from a deck compression chamber following 20-hour decompression which concluded a 2-month stay beneath the ocean surface in Project Tektite I.

Tektite I was intended to establish guidance for future submerged laboratory projects. It established baselines for prolonged exposure at 50 feet for 2 months and set the stage for deeper dives of longer duration. Plans have been announced for a follow-on project, Tektite II, in the spring of 1970. Led by the Department of the Interior, a number of Federal agencies, universities, and the Government of the Virgin Islands will take part in the project. In this experiment the Tektite habitat will be resubmerged at the same depth and location for 7 months. During this period approximately 62 marine scientists and engineers, including some from other countries, will work in small teams for 2- to 4-week periods underwater. Direct costs of Tektite II for fiscal years 1970 and 1971 are estimated at $1.1 million.

Tektite II experiments will be conducted at greater depths and for longer durations than its predecessor project. The Tektite habitat will be augmented by a smaller, two-man dwelling anchored nearby at a depth of 100 feet.

Solving Crucial Problems

The problems of living and working beneath the ocean's surface are formidable; they are primarily the biomedical problems related to survival and technological problems associated with the design and operation of facilities for working underwater.

The biomedical problems stem directly from the wet, cold, dark and high pressure environment. The severe and potentially disabling or lethal physiological changes which occur during diving have prompted the search for practical solutions and are the stimulus for much of the basic research. Perhaps the most significant of these problems today is decompression sickness, caused by the release of gas from the tissues, in which gas has dissolved at the hyperbaric pressure of the dive. This release happens if ascent occurs more quickly than the rates at which gas will leave all body tissues and remain in solution. Practically, the decompression time of many days required for dives to 1,000 feet severely limits the economic value of diving to such depths.

Other severe diving problems are oxygen toxicity, carbon dioxide buildup in the lungs, inert gas narcosis and work limitation caused by increased gas density. Cold water chilling may be severe. Visibility and orientation may be poor in murky water. Speech becomes unintelligible when divers breathe helium/oxygen gas mixtures at high pressure. Failures of equipment or other emergencies can be fatal. Long-term problems relate to composition and palatability of food, psychological effects during isolation, and crowding in small spaces.

Conducting Needed Research

Current knowledge and research in many of these areas is still limited. In the past 3 or 4 years, there has been a more rapid growth in the study of underwater physiology and medicine and of man-in-the-sea development as a whole. Most of the support and effort in this field has come and continues to come from the Navy. In addition to the Navy's program, focal points of

biomedical research have been at productive undersea research centers at the University of Pennsylvania at Philadelphia and at the State University of New York at Buffalo. The hyperbaric center at Duke University is the site of joint and continuing Duke-U.S. Navy saturated diving experiments.

Other research centers have been established as follows: a hyperbaric facility at the Virginia Mason Research Center, Seattle, Wash.; the Wrightsville Marine Biological Laboratory, Wrightsville Beach, N.C.; and the Marine Biomedical Institute at Galveston, Tex. The Undersea Medical Society was formed in 1967 and is now active with over 450 members.

The main focus of the Navy's effort in the biomedical area is in its ocean engineering programs. It consists of efforts in the man-in-the-sea project and the biomedical programs of the Bureau of Medicine and Surgery and the Office of Naval Research.

The biomedical and life science programs are directed toward maintaining the diver as an effective functional unit in the stressful environment of modern naval operations. Experimental dives in chambers and at sea have been made beyond the 1,000-foot level. It appears that divers will be able to perform useful work at depths of 1,000 feet and somewhat beyond provided the technology and diving equipment are sufficiently developed to maintain them for the long durations required for compression and decompression and so long as improvements are made in communications, thermal balance, guidance, and navigation. Diving much deeper than 1,200 feet will certainly be achieved, but the depth and rate will depend upon the support available for needed basic and applied technological and biomedical research. One possible solution—though a radical one—may be liquid breathing.

The principal laboratories participating in the program are the Naval Medical Research Institute, the Navy Submarine Medical Research Laboratory and the Experimental Diving Unit. The Navy Medical Research Institute program is devoted to undersea biomedical research and investigations of decompression sickness, inert and other gas physiology, hyperbaric biochemistry, thermal problems, microbiology and toxicology, psychology, and biophysics.

The Submarine Medical Research Laboratory is investigating submarine escape, diving physiology, crew selection and performance and hearing and vision. The Experimental Diving Unit tests both new diving techniques and equipment, and provides decompression chambers with a 1,000-foot wet and dry depth capability.

In the civil sector of the man-in-the-sea program, the University of Pennsylvania Institute of Environmental Medicine has conducted many of the studies on which current knowledge of the physiology of diving is based. It has also trained naval scientists engaged in undersea medical research. The State University of New York has been the leader in unraveling the fundamental mechanisms of respiration in the hyperbaric environment.

Developing Needed Support Systems

In the past, advances in physiological knowledge and technological development have often alternated in allowing man to go further and deeper

into the sea. Today, diving performance at depth is partly limited by the lack of advanced diving equipment, including life support systems.

In the Navy, such research and development is carried out under the ocean engineering program, and includes the development of equipment for navigation, communications and control, swimmer and diver support, and life support and protection and life support equipment. Total expenditures under this program were $4.5 million in fiscal year 1967, $4.0 million in fiscal year 1968, and $6.8 million in fiscal year 1969. The majority of the Navy diver support development work is carried out at three laboratories: The Naval Ship Research and Development Laboratory at Panama City, Fla., which emphasizes man-machine relationship, diver guidance and navigation, underwater transportation systems and techniques for improvement of underwater vision; the Navy Undersea Research and Development Center, San Diego, which concentrates on communication equipment and onsite testing of saturated diving systems; and the Naval Civil Engineering Laboratory, Port Hueneme, which develops diver tools and construction equipment.

The simulation of the undersea environment is carried out in hyperbaric chambers, some of which are large complexes costing millions of dollars. Hyperbaric chambers are used for clinical medical studies, physiological research, operations and equipment experiments, and for operational military and industrial purposes.

In the industrial field, larger chambers are used for training, for research and for equipment development. Smaller chambers, used for training and treatment of stricken divers, number over 100. A listing of hyperbaric facilities and locations is given in appendix F.

The Navy plans to construct three hyperbaric chambers with dry and wet capability and 2,000-foot operation depths. Construction will begin on the facility at the Navy Submarine Medical Center in fiscal year 1971. Construction has already begun on a large unit at the Naval Ship Research and Development Laboratory, Panama City, Fla., for equipment development and testing and man machine studies. The third unit is planned for use by the Naval Medical Research Institute, Bethesda, Md.

Growing Problems of Diver Safety

As the number of divers increases and their diving depths go deeper, the need for better safety measures also grows. Sealab III was delayed early in 1969 because of a diver fatality, one of the regrettable prices of progress in pioneering a hostile environment. Given the harsh conditions under which commercial divers operate it is not surprising that the incidence of death and sickness is high. Mortality figures among commercial divers are estimated at between five and 50 each year. High insurance rates—as high as $30 for every $100 of pay earned—reflect this problem. The Marine Technology Society is seeking to develop in association with the United States of America Standards Institute minimum standards for commercial diving. Hopefully, effective standards will be accepted and implemented by industry.

The safety problem among amateur divers is becoming more serious. This is particularly so because of the great growth in the number of amateur divers. From an estimated 2 million amateur divers in 1970 the numbers are expected to rise to 5 million in 5 years and to 10 million by the end of the decade. Many of these divers will soon be attracted to complex saturated diving at greater depths. In 1965, the Public Health Service recorded only 86 deaths among skin and scuba divers, most due to overextended submersion and panic. While mortality figures for later years have not been reported they are believed to be higher. In 1967, for instance, the Navy treated 21 civilians and 46 military personnel in its decompression chambers. Such figures indicate a need for greater concern about diving safety.

Heightening this concern is the variability of standards in training and equipment use and maintenance. No uniform national standards exist for levels of scuba proficiency among divers or instructors, except for those set by various organizations such as the National Association of Underwater Instructors, YMCA, Boy Scouts of America, several Government laboratories, institutes, and universities. The city of Los Angeles has found it necessary to adopt and enforce regulations locally.

The Coast Guard is concerned with such problems because of its responsibility for safety of life and property at sea. The Coast Guard is participating in the American National Standards Institute's work in developing minimum standards for diving safety. The Council for National Cooperation in Aquatics is sponsoring an American National Standards Institute project to develop minimum standards for recreational diving. Adherence would be voluntary. In light of the growing number of divers, efforts to provide adequate safety standards must be pursued diligently.

A Sound National Program

While much progress has been made in man-in-the-sea activities in recent years, additional steps may be needed to—

(1) Expand exploratory oceanographic studies to assess the value of free diving and mobile and fixed habitats;

(2) Create improved safety measures, especially for recreational diving;

(3) Strengthen the long-range biomedical program;

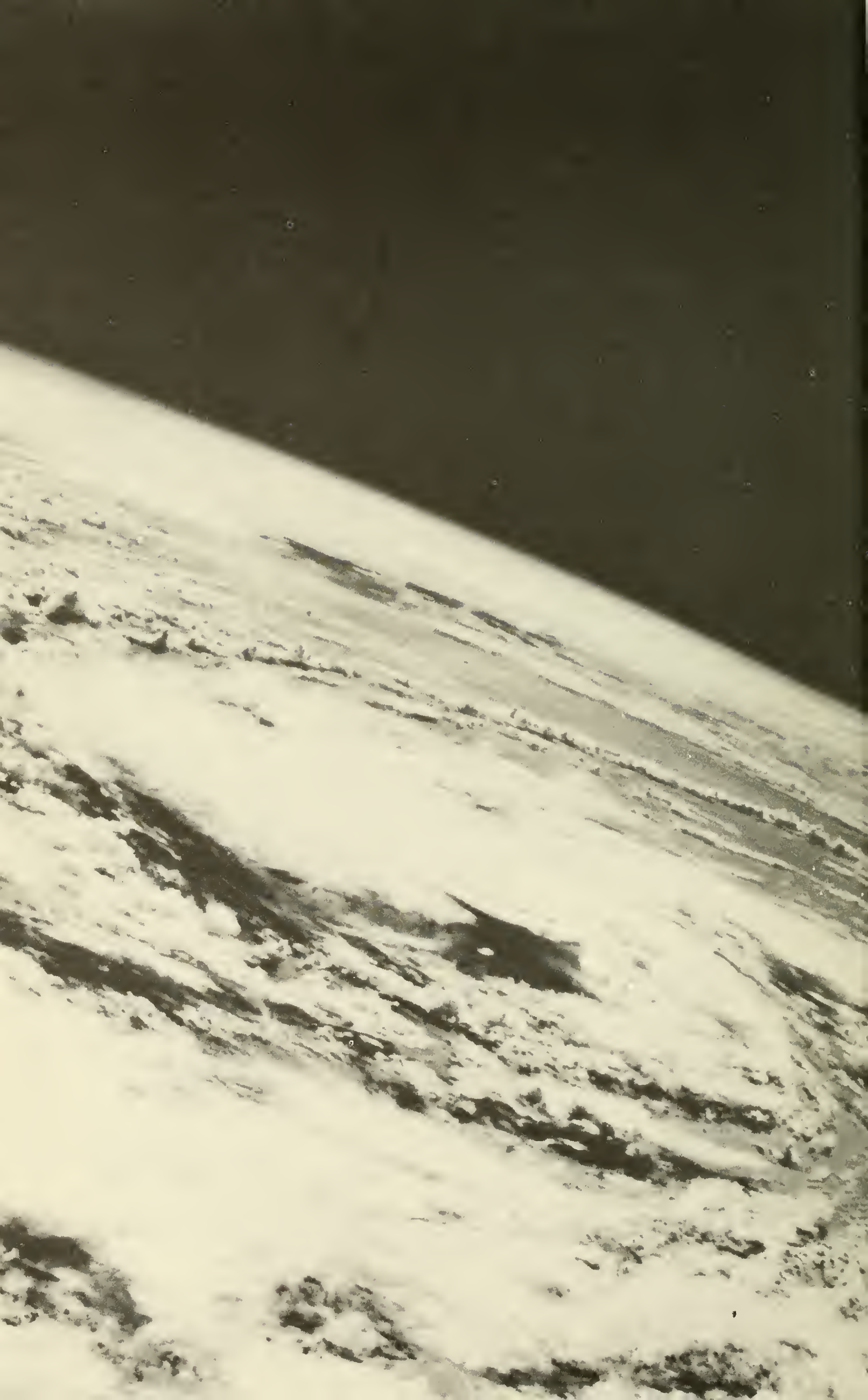
(4) Develop a coordinated program to advance technology;

(5) Encourage support for education and training of technicians, divers, scientists, engineers and medical doctors in man-in-the-sea activities;

(6) Coordinate institutional and group man-in-the-sea activities;

(7) Foster cooperation and communication, nationally and internationally, for man-in-the-sea activities; and

(8) Conduct long range research to evaluate the effects of man on the ocean's ecology and resources.



Chapter IX

SURVEYING AND PREDICTING THE OCEAN ENVIRONMENT

In practical daily applications of oceanic knowledge, no single factor is more important than a solid foundation of data. The assessment and recovery of both living and nonliving resources can proceed effectively only when there are adequate base maps from which to work. More efficient sea transportation vitally depends upon portfolios of accurate nautical charts and publications for the open ocean as well as coastal ports and waterways. Efforts to halt pollution and improve the utilization of the coastal zone must start from these factual baselines. International, oceanic, legal, and political questions often require facts available only from precise maps and accurate marine data if they are to be answered.

In addition to acquiring this comprehensive body of data, it is even more important that the United States be able to extrapolate from the knowledge gained—to forecast oceanic phenomena in the future and to predict reliably what conditions will be in areas as yet unexplored. It is particularly important that the Nation improve its capability to predict changes in those factors which are time dependent. A fisherman may be mildly interested in the past history of the Gulf Stream, but he is deeply concerned with where its northern edge will be tomorrow, when he will be looking for the fish which concentrate at that boundary. A naval staff can base its general plans for wartime convoys on historical data, but the sonar operator on a destroyer must know what the acoustic conditions will be in his local area during the next few hours.

The acquisition of information for the data base, its handling and presentation, and its conversion into forecasts of future events, cannot proceed independently. Research and development to improve acquisition techniques, methods of data handling, and predictive ability are dependent upon a fuller understanding of oceanic processes. The development team must include surveyors, forecasters, and researchers working together to provide present and potential users with these critically important building blocks.

Mapping, Charting, and Geodesy

Many features of the ocean, fortunately, vary so slowly that surveys can be conducted and prepared which will be valid for many years. While

The danger and destruction forces of hurricanes—such as Hurricane Gladys, here seen from Apollo 7—point to the need for effective environmental prediction.

Table IX–1—Potential Users of Ocean Environment Survey Data

Survey observations	Potential users of survey data										
	Fisheries and aquaculture	Transportation	Seabed minerals	Seawater minerals	Pollution control	Recreation	Conservation	Coastal development	Defense	Environmental forecasting	Basic research
Temperature	X	X	X	X	X	X	X	X	X	X	X
Radiation	X	------	------	X	X	X	------	------	X	X	X
Tides	X	X	X	X	X	X	X	X	X	X	X
Currents	X	X	X	X	X	X	X	X	X	X	X
Turbulence	------	------	X	------	X	------	------	------	X	------	X
Waves	X	X	X	X	X	X	X	X	X	X	X
Color	------	------	X	X	X	X	X	------	X	------	X
Transparency	X	------	X	X	X	X	X	------	X	------	X
Ambient light	------	------	X	------	X	X	------	------	X	------	X
Ice	X	X	X	X	X	X	X	X	X	X	X
Density	------	------	X	X	X	------	------	------	X	X	X
Sound velocity	X	------	X	------	------	------	------	------	X	X	X
Ambient noise	------	------	------	------	------	------	------	------	X	X	X
Volume reverberation	X	------	------	------	------	------	------	------	X	X	X
Bottom acoustic loss	------	------	------	------	------	------	------	------	X	X	X
Meteorology	X	X	X	X	X	X	X	X	X	X	X
Depth	X	X	X	X	X	X	X	X	X	X	X
Microrelief	X	------	X	------	X	------	------	X	X	------	X
Sediment engineering	X	X	X	------	X	X	------	X	X	------	X
Surface sediments	X	X	X	X	X	X	X	X	X	X	X
Deep sediments	------	------	X	------	------	------	------	X	X	X	X
Bottom photographs	X	X	X	X	X	X	X	X	X	------	X
Heat flow	------	------	------	------	------	------	------	------	X	------	X
Mineral resources	------	------	X	X	------	------	X	------	------	------	X
Geochemistry	------	------	X	X	X	------	------	X	X	------	X
Subbottom reflections	------	------	X	------	------	------	------	X	X	X	X
Subbottom refractions	------	------	------	------	------	------	------	------	X	X	X
Magnetism	X	X	X	------	------	------	------	------	X	------	X
Gravity	------	------	X	------	------	------	------	------	X	------	X
Telluric currents	------	------	X	------	------	------	------	------	X	------	X
Salinity	X	X	X	X	X	X	X	X	X	X	X
Nutrients	X	------	------	------	X	X	X	X	X	------	X
Dissolved gases	X	------	X	X	X	------	------	------	X	------	X
Radioactivity	X	------	X	X	X	------	X	------	X	------	X
Pollutants	X	X	X	X	X	X	X	X	X	X	X
General chemistry	X	X	X	X	X	------	X	X	X	X	X
Trace elements	X	------	------	X	X	------	------	------	------	------	X
Plankton sampling	X	------	------	------	X	X	X	X	X	X	X
Nekton sampling	X	------	------	------	X	X	X	X	X	X	X
Benthic dredging	X	------	X	------	X	X	X	X	X	X	X
Experimental fishing	X	------	------	------	X	X	X	------	X	X	X
Fouling	X	X	X	------	X	X	------	X	X	------	X
Animal sounds	X	------	------	------	------	------	X	------	X	X	X
Bioluminescence	X	------	------	X	------	X	X	------	X	------	X

much progress has been made in the areas covered by basic surveys, there are still large sections of the ocean of which we know only the gross features. Field acquisition of data has been concentrated in those areas of primary concern—the coastal zone, major trade routes, potential naval operating locations, and sites of intense research interest. In terms of bathymetric information, less than one-fifth of the ocean bottom has been surveyed in detail; for most other oceanographic factors, the state of knowledge is even more sketchy. As a result, the basic maps for economic development, national defense, and scientific research are often inadequate.

Mapping, charting, and geodesy account for approximately 13 percent of the marine sciences budget for fiscal year 1971 (table IX–2). Many agencies conduct mission-oriented surveys, with Navy and the Department of

Commerce's Environmental Science Services Administration (ESSA) providing most of the general purpose charts. During the past year, ESSA was assigned lead agency responsibility for mapping, charting, geodesy, and data storage.

Table IX-2—Funding for Mapping, Charting, and Geodesy

[In millions of dollars]

Agency	Estimated fiscal year 1969	Estimated fiscal year 1970	President's budget fiscal year 1971
Department of Defense	60. 7	66. 7	50. 7
Navy	(59. 0)	(65. 9)	(49. 6)
Corps of Engineers [1]	(0. 8)	(0. 8)	(1. 1)
Department of Commerce	18. 5	22. 3	23. 6
NASA	0. 4	0. 4	0. 4
Total	79. 7	89. 4	74. 7

[1] Charting of the Great Lakes.

Hurricane Camille's trail of devastation along Mississippi's Gulf Coast left many marks such as this beached shrimp trawler.

The research programs supported by the National Science Foundation and the Navy at institutions and universities produce quantities of data which are often useful in the production of charts and atlases. Those surveys which are particularly oriented to defense systems, resource development, and other end-uses are described in detail in other chapters of this report. Of the multipurpose surveys undertaken during 1969, the following were of major interest:

1. ESSA continued its surveys of the U.S. coast and the deep ocean, concentrating its efforts off New England, North and South Carolina, Puerto Rico, Washington, Alaska, and the Hawaiian Islands. Special attention was given to inshore hydrographic investigations along the Atlantic and Gulf coasts, where demands for small-craft charts are rapidly growing. Because of extensive changes in the marine topography and possible navigational hazards resulting from hurricane Camille, selected areas of the Gulf coast were resurveyed and recharted. The SEAMAP project involving acquisition of bathymetric and geophysical data continued in the northeast Pacific.

2. ESSA published seven new nautical charts and issued 487 corrected editions. In consultation with the Department of Defense, ESSA released several previously classified Alaskan charts for public use. A bathymetric map, with two geophysical overlays, was published for Norton Sound, and two other bathymetric maps were published for the California-Oregon coast. Bathymetric maps are also being prepared for parts of the Gulf of Maine and off-shore regions along the North Carolina coast.

3. Instrumentation to measure waves in the tsunami spectrum in the open ocean was developed and tested by ESSA.

4. The Bureau of Commercial Fisheries continued its extensive surveys and monitoring of oceanographic conditions, concentrating its work on the Eastern Bering Sea, Aleutian Island area, Gulf of Alaska, Hawaiian Islands area, Eastern Pacific Ocean, the Caribbean Ocean, and the areas off Florida and the New England coasts.

5. The Bureau of Commercial Fisheries published an oceanographic atlas of the Pacific Ocean. Summarizing 50 years of work, it is based on 50,000 oceanographic stations and 3 million individual observations. Because of fishery implications, it is primarily concerned with the uppermost mile of water.

6. The Navy produced 110 new charts for general navigation, 67 special charts for surface fleet and submarine use, over 700 corrected charts, and numerous accessory publications. Of particular note is the Navy's production of 87 new charts based on surveys and charts made by other countries, the materials for which were acquired through the bilateral chart reproduction exchange program.

7. The Navy conducted a major survey of the Pacific Trust Territories at Palau, Ulithi, Truk, and Ponape, along with other investigations in the Western Pacific and the Hawaiian Islands. The first third of a 3-year coastal survey of South Korea was also carried out. Deep-ocean bathymetric and geophysical surveys were conducted in the North Atlantic, Western Pacific, and off both coasts of the United States collecting almost 500,000 miles of bathymetry and geophysical data.

8. The Navy's university research effort included development of a shipboard vibrating-string gravimeter which is easily transportable, economical, and more accurate in heavy seas than present equipment. A small ancillary computer processes and displays data on the spot.

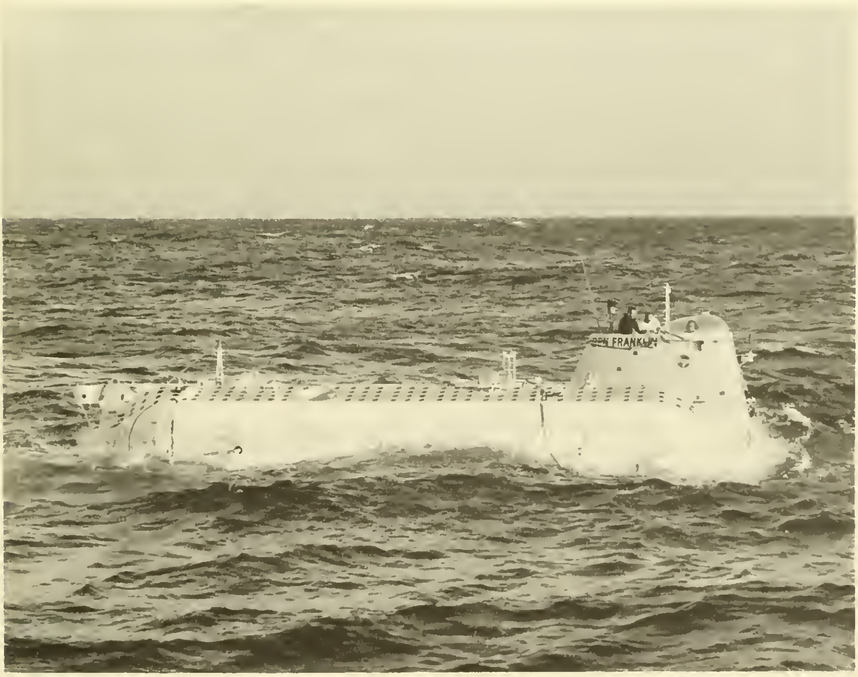
9. Navy and ESSA tested new high-speed hydrographic sounding launches with automatic digital positioning and depth recording systems. The Navy transmitted multicolored navigational charts by high-resolution facsimile through a satellite-linked communications network.

10. The Coast Guard continued its program of outfitting its cutters to make them fully suitable as survey platforms. Salinity-temperature-depth recording systems are being installed, and the majority of the ships now have hydrographic winches. Data collection continued both for specific projects and as a routine task assigned to Coast Guard cutters.

Gulf Stream Drift Mission

Of the many ocean operations conducted during 1969, one—the Gulf Stream drift of the submersible *Ben Franklin*—was of particular note because of its novel approach to a complex problem and its collaborative achievement involving government, industry and academic participants.

On July 14, 1969, the manned submersible *Ben Franklin* submerged into the Gulf Stream off West Palm Beach, Fla. For 30 days she drifted im-



The Ben Franklin *is seen undergoing sea trials prior to her unique month-long submerged drift in the Gulf Stream from Florida to Canada.*

mersed in the Gulf Stream, finally to surface south of Nova Scotia. The submersible is owned by Grumman Aircraft Corp.; the expedition was carried out in cooperation with the Navy and NASA. Not only was the project an industry-government partnership, it was also international in flavor; in addition to the embarked U.S. personnel, the chief scientist was Swiss, and the acoustician British.

The primary purpose of the drift mission was to demonstrate the *Ben Franklin*'s ability to operate and sustain the crew of six for a long period, and to conduct oceanographic observations submerged for extended times. The Navy's prime interest was in the instrumentation suite, while NASA's interest stemmed from the similarity of the craft to a space station with the resulting opportunity to study the effects of the extended period of isolation and confinement on human beings.

From a scientific point of view, the mission provided the opportunity for a unique kind of sampling. Scientists have long studied the ocean's characteristics by sitting at one point and letting the water go by; the *Ben Franklin* cruise, on the other hand, stayed with a body of water over a long period of time, riding in it as it moved through the ocean, and observing changes that took place during the period.

The Gulf Stream's speed, local turbulence, and physical and acoustic properties were investigated through observations and recordings of almost 1 million measurements of temperature, sound velocity, and salinity along the track. Stereophotographs of the bottom were taken at five locations, as well as side-scan sonar imagery of the bottom, along with measurements of the acoustic reflectivity of the ocean bottom and the volume reverberation coefficient of the water at selected locations.

The Gulf Stream drift mission accomplished its primary objectives of sustained submergence and of identifying problem areas. With only few exceptions, life support systems worked well. Carbon monoxide accumulation and bacterial growth occasionally posed problems, but remained within acceptable limits. Various components of the suite of equipment failed at various times, and the need for specific corrective actions was thus identified.

Federal Leadership for Environmental Predictions

The sea and the air form a closely knit physical complex, operating under similar physical laws, in which changes in one strongly influence the actions of the other. Much of the Nation's capability for the prediction of oceanographic factors has evolved in meteorological forecasting centers and the two activities are often co-located. Federal agency funding for programs in support of environmental forecasts and associated observations is shown in table IX–3.

In 1969 a Federal Planning Guide for Marine Environmental Predictions (MAREP), which had been completed by the Council's Interagency Committee on Ocean Exploration and Environmental Services, was reviewed by

Table IX-3—Funding for Ocean Observation and Prediction

[In millions of dollars]

Agency	Estimated fiscal year 1969	Estimated fiscal year 1970	President's budget fiscal year 1971
Department of Defense	12.1	11.6	11.5
Navy	(11.8)	(11.3)	(11.1)
Corps of Engineers	(0.3)	(0.3)	(0.4)
Department of Commerce (ESSA)	7.0	6.7	7.7
Department of Transportation (Coast Guard)	11.7	11.0	11.4
NASA	1.5	1.4	1.4
Atomic Energy Commission	1.4	1.0	0.8
Total	33.7	31.7	32.8

the agencies concerned. This planning guide, which is still under study, is an evolutionary step toward the identification of requirements and the development of a Federal plan for providing a cohesive and effective set of environmental predictive services. MAREP addresses not only the technical factors involved—the physical, biological, and hydrodynamic states of the ocean and atmosphere—but also the identification of existing marine environmental prediction activities; and a preliminary statement of current and future user requirements. Considerable study and refinement of requirements must take place before actual program planning can commence. The benefits and alternative methods of satisfying high-priority requirements must still be identified and evaluated. Nevertheless, MAREP can serve as a basis for such activity in this important area.

The Department of Commerce was assigned lead agency responsibility for civil marine environmental observation and prediction activities, and submitted an implementation plan which included these major points:

1. The Department of Commerce (ESSA) would serve as lead agency for Federal marine environmental prediction activities, excluding the Department of Defense activities which involve military security or which are of uniquely military concern.

2. The Administrator of ESSA would serve as Federal coordinator for MAREP, with staff to be provided by the Office of the ESSA Assistant Administrator for Environmental Systems.

3. To assist the Federal coordinator in carrying out his responsibility, an Interagency Committee for Marine Environmental Prediction (ICMAREP) would be established with Chairman and Executive Secretary to be provided by ESSA's Office of Environmental Systems.

4. The Federal coordinator would report to the Marine Sciences Council's Committee for Policy Review for policy guidance, review and validation of proposed plans, and the resolution of differences which might arise.

This plan was considered and approved by the Council's Committee for Policy Review in December 1969.

As noted elsewhere in this report, the President's five-point marine sciences program places emphasis on environmental forecasting and ocean monitoring programs as areas of special interest to the United States in the International Decade of Ocean Exploration.

A cage of instruments for measuring salinity, temperature, depth and other oceanographic factors is lowered from the Navy's survey ship Silas Bent. *Data from the instruments are fed into the Shipboard Survey System, where they are recorded, corrected, and displayed in a matter of minutes.*

The Navy and ESSA are developing oceanographic prediction programs with the following recent achievements:

The first ESSA Marine Forecast Center was established at Anchorage, Alaska. It provides seafarers along the Alaskan coast with six broadcast bulletins daily, each containing weather patterns, forecasts of waves, temperature, visibility and sea ice, and warnings.

Observations of Gulf Stream meandering were tested by ESSA against several theories about the origin of these phenomena; it appears, however, that none of these theories is adequate, and that further basic work is needed.

During studies of the general circulation of the Gulf of Mexico, ESSA took advantage of a rare opportunity to investigate oceanographic conditions immediately before and after a hurricane passage. These observations will contribute substantially to our knowledge of both the causes and effects of such storms.

BCF Fishery Oceanography Center's forecasting service completed its ninth consecutive year of providing monthly and 15-day oceanographic charts of environmental conditions off the west coast of the United States.

Correlation of sea surface temperature gradients with subsurface thermal structure was undertaken by ESSA. This method has great potential value in the use of satellite observations of sea surface temperatures to predict subsurface thermal structures.

In 1969, the Navy extended and improved its capability in both general and specialized environmental forecasts. Many numerical models of nature were completed for the prediction of surface waves, ice movement, air-sea interactions, and acoustic propagation phenomena and sonar range forecasts. Culminating years of research, these models appear to be sufficiently accurate for application to practical problems, although additional validation is required. A numerical, computerized model was also developed for prediction of sea and swell both for coastal waters and for semi-enclosed seas. A computer-based prediction model which relates environmental data to the growth and decay of sea ice, was tested for reliability. Perhaps of greatest significance, a system was established for evaluation of numerical oceanographic forecasts by naval units to provide the basis for pragmatic refinement of models.

Data were gathered by the Navy to test a model for the generation and propagation of internal waves, which appear to be major contributors to motion in the deep ocean.

Developing Buoy Technology

A large part of the construction and operational costs of seagoing platforms is directly related to the provisions of accommodations for operators. Accordingly, the desirability of utilizing automatic sensing, recording and telemetering equipment whenever feasible, thus avoiding expensive life-support systems, is evident. While buoys and other unmanned platforms cannot replace manned platforms in all situations, it is clear that they have a role in the data collection program which will increase as our technology for automated sensing improves.

The Coast Guard, as lead agency in development of data buoy technology and determination of system requirements, worked in close collaboration with other agencies on advanced system development during 1969. Efforts in this program covered preparation of a long-range development plan; initial engineering for experimental test platforms; design requirements for prototype buoys; analysis and evaluation of sensors; and mission and benefit analyses. The advanced development phase, as now planned, contemplates initial deployment of experimental buoys in 1971, testing of prototype low-capability buoys in 1972, and evaluation of improved state-of-the-art high-capability buoys in 1973. Some noteworthy events during the past year included—

(1) Selection and direction of systems engineering and management support efforts to develop a long-range program plan;

(2) Systems planning and budgetary justification, including a tentative performance requirement, a preliminary concept formulation sum-

mary, and two engineering studies of alternative technical approaches to meet the performance requirements;

(3) An in-depth study of optimum utilization of the six high-frequency radio bands available for oceanographic use, and telemetry propagation reliability from potential buoy locations;

(4) Studies to refine user requirements, to investigate observational data characteristics, to examine the natural variability of important factors in the marine environment, to compare cost-effectiveness sensitivities of various mixes of observational platforms, and to examine deployment and maintenance schedules and operational tradeoffs;

(5) Participation in the Navy North Pacific experiment, by providing ship support, and installing VHF telemetry equipment for real-time data relay via satellite;

(6) Examination in depth of the benefits obtainable for all types of transportation from improved environmental predictions; and

(7) A Scientific Advisory Committee meeting to relate buoy capabilities to the solution of major environmental research problems, and to discuss relationships with planned national and international programs.

Previous efforts have provided a sound base for specific project funding of $6.5 million in fiscal year 1970 and $13.5 million in fiscal year 1971. The current year's work is providing a start on engineering test platforms and studies for improved platform and sensor design.

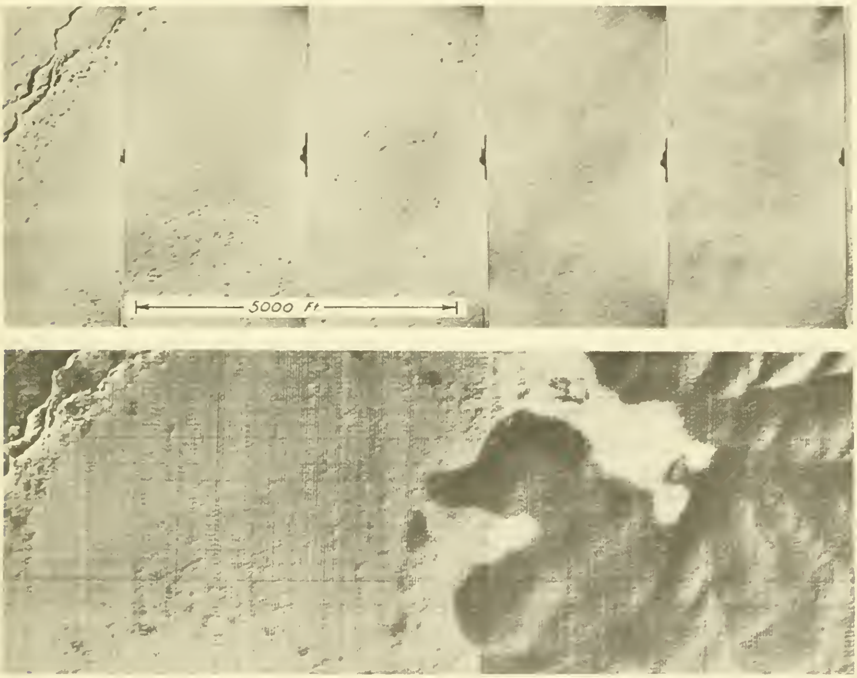
Employing Spacecraft and Aircraft

When the problems of the ocean are viewed on a global scale, it is apparent that aircraft and spacecraft can serve as powerful tools which can contribute significantly to the solution of ocean problems. From the unique vantage points offered from the air and space, quasi-synoptic, repetitive looks can be taken at immense geographical areas. Many technical difficulties persist and there are physical limitations to a high-altitude sensor's capabilities to look into the sea. But in the decade since earth orbital activity began, great progress has already been made toward marine science applications of the Nation's space program. Activities in this field are reported in the publication "United States Activities in Spacecraft Oceanography," prepared for the Marine Sciences Council by NASA, the Navy, ESSA, and BCF in 1967.

Most of the current effort is being concentrated on determining the capabilities and limitations of remote sensors on spacecraft. The development of sensors with optimum spectral and spatial resolution to sample discrete areas on the sea surface, to avoid too much "averaging" and loss of detail, must be reconciled with the desirability of fully utilizing the unique capability of spacecraft for broad-area coverage. The calibration of equipment in use has posed a particular problem; considerable effort has been necessary to provide "ground truth" locations over which flights can be made, so that surface and high-altitude results can be compared. Data handling is unusually complex, the large quantities of data acquired leading to massive storage, transmission and processing problems. Much interpre-

tative work is presently underway on the application of data gathered for specific oceanic uses such as fisheries, charting, transportation, and defense.

The National Aeronautics and Space Administration as the lead agency responsible for coordination of space sensor technology, techniques for space oceanography, and testing of new developments, continued its activities in these areas during 1969. The Spacecraft Oceanography Project Office, established at the Naval Oceanographic Office under a NASA/Navy agreement, continued to provide support by monitoring NASA developmental contracts, conducting technical symposia, and coordinating working-level agency interests. Interagency coordination was effected through the Earth Resources Survey Program Review Committee.



The effective employment of new techniques, such as infrared thermal imagery is shown in these photographs. Conventional aerial photography (top) and infrared thermal imagery (below) taken at midday under ideal photographic conditions. The shoreline was not distinguishable in detailed stereoscopic study of the photograph. However, thermal imagery of the coastline corresponds exactly to that shown in summer photography.

Many of the problems associated with sensing the ocean from high altitudes, and the techniques for solving them, are common to both aircraft and satellites. Because of this commonality, many current experiments are being carried out from aircraft due to their greater flexibility and lower cost. During the past year, emphasis was placed on the testing of sensors over specific ocean test sites. Among the activities relating to both airborne and satellite systems were the following:

1. Missions were flown to obtain radar scatterometry data over various sea

conditions, using NASA and Navy aircraft. Ground truth to verify and interpret the radar data was provided by laser altimeters and by foreign weather station ships.

2. Ocean swell measurement techniques from space photography were developed by Navy.

3. Detailed analyses of visible regions and high-resolution infrared imagery from the Nimbus II satellite were completed, demonstrating the feasibility of mapping the distribution of sea ice by these techniques.

4. The Navy's tests of a ruby laser for sea-ice profiling resulted in remarkable resolution accuracy of 6 inches. Matched with coincident photography the laser tests demonstrated that ice roughness and surface reflectivity offered promising indications for use in interpreting stages of ice development.

5. The Bureau of Commercial Fisheries demonstrated the utility of low-light-level TV to detect bioluminescence generated by both individual and schooling fish. Fisheries experiments were conducted using photography, infrared radiometers, and multispectral imagery to map sea surface temperatures and areas of upwelling off the Columbia River. Spectrometer signatures were established for several species of fish in the Gulf of Mexico.

6. Multiband photography was flown over the submersible *Ben Franklin* to gain information on the visibility of her hull at various depths and at various parts of the spectrum.

7. The Navy tested techniques for measuring volume reverberation (the scattering and random echoes of acoustic pulses in the ocean) from aircraft, using modified ASW sonobuoys and explosive sources of sound. Work is underway to extend these techniques to the measurement of bottom loss (the amount of acoustic energy lost or dissipated when an acoustic pulse is bounced off the ocean bottom). Both of these factors are of critical importance to the new, high-powered sonar systems, which are designed to project sound either directly through the water mass, or reflect it off the bottom if this is advantageous operationally against submerged submarine targets.

8. Aircraft expendable bathythermographs were used routinely by the Navy for synoptic and quasi-synoptic measurement of large-area ocean temperature profiles.

9. A wide-range imaging spectrophotometer and water color spectrometer were flown over test sites, providing data on absorption spectra for polluted waters, mineral and fish oil slicks, chlorophyll, and water mass types.

10. An interrogating, recording, and locating system was used to demonstrate continuous, reliable ocean data telemetry. Data acquired by sensors on buoys and ships and the sea platform's position were telemetered on inquiry to a Nimbus satellite which further relayed them to a land-based processing computer.

11. Two Navy magnetic survey aircraft collected almost 250,000 miles of airborne magnetic data on worldwide flights.

National Oceanographic Instrumentation Center

Implementing a decision taken by the Marine Sciences Council the National Oceanographic Instrumentation Center was formally established on February 13, 1969, with the mission: "To act as the National focal point

for knowledge of technology related to the testing, evaluation, and calibration of sensing systems for ocean use, to enhance the quality of such systems by the dissemination of operational results and technical information, in order to serve the national oceanographic community."

The Instrumentation Center is under the administrative command of the Naval Oceanographic Office, and is guided in its policy by an advisory board with membership from Federal agencies concerned, as well as observers from the National Academies of Sciences and Engineering. The center is assigned to—

(1) Operate a laboratory for the evaluation of oceanographic instruments;

(2) Generate a central proposal and specification file and disseminate information on ongoing development efforts for oceanographic information;

(3) Encourage the coordination of national specifications for oceanographic instrument development;

(4) Conduct cooperative programs among Government agencies, the academic laboratories, and the industrial community for the purpose of compiling Government-wide requirements on instruments to support the development of standards;

(5) Establish the techniques and secondary reference standards by which oceanographic instrument performance can be assessed;

(6) Perform laboratory and field testing and calibration of oceanographic instruments for government, academic, and industrial interests;

(7) Collect and disseminate instrument performance and deterioration data as a means of acquiring statistically significant samples on which to base design criteria for improved systems; and

(8) Develop ocean measurement instruments, when these instruments cannot be obtained from other sources, and equipment needed in the testing and calibration of oceanographic instruments.

The National Bureau of Standards in cooperation with the instrumentation center plans to assist by providing fundamental and transfer standards of physical measurement, and the precise determination of physical constants and important properties of matter and materials as they relate to the ocean.

During 1969, the center performed nondestructive tests on 25 instruments of varying types, ranging from depth recorders to salinometers, and from current meters to acoustic releases. As in past years, a high percentage failed to meet manufacturer's specifications. Thirteen fact sheets were issued on equipment tested, to assist users in making choices, and to help manufacturers improve their products. Subject to availability of funds, the center plans to increase the output of this service during the coming year, and to implement other functions of the center's charter.

Establishing Future Priorities

The seemingly simple activities of charting the ocean and predicting its future actions are in fact the most massive and intractable problems which now face marine scientists. At our present rate of progress, mapping the

ESSA's Oceanographic Survey Ship Explorer (OSS–01) *is typical of the new oceanographic vessels being constructed. Since these ships are designed specifically for their tasks, they are more productive and efficient than the older ships they replace.*

topography of the ocean bottom will involve hundreds of ship-years of work. Delineation of other static factors, including the assessment of resources, will require equally great efforts. Statistical surveys of the time-dependent variables, and the understanding of ocean processes sufficient to permit improvements in their prediction, are far in the future.

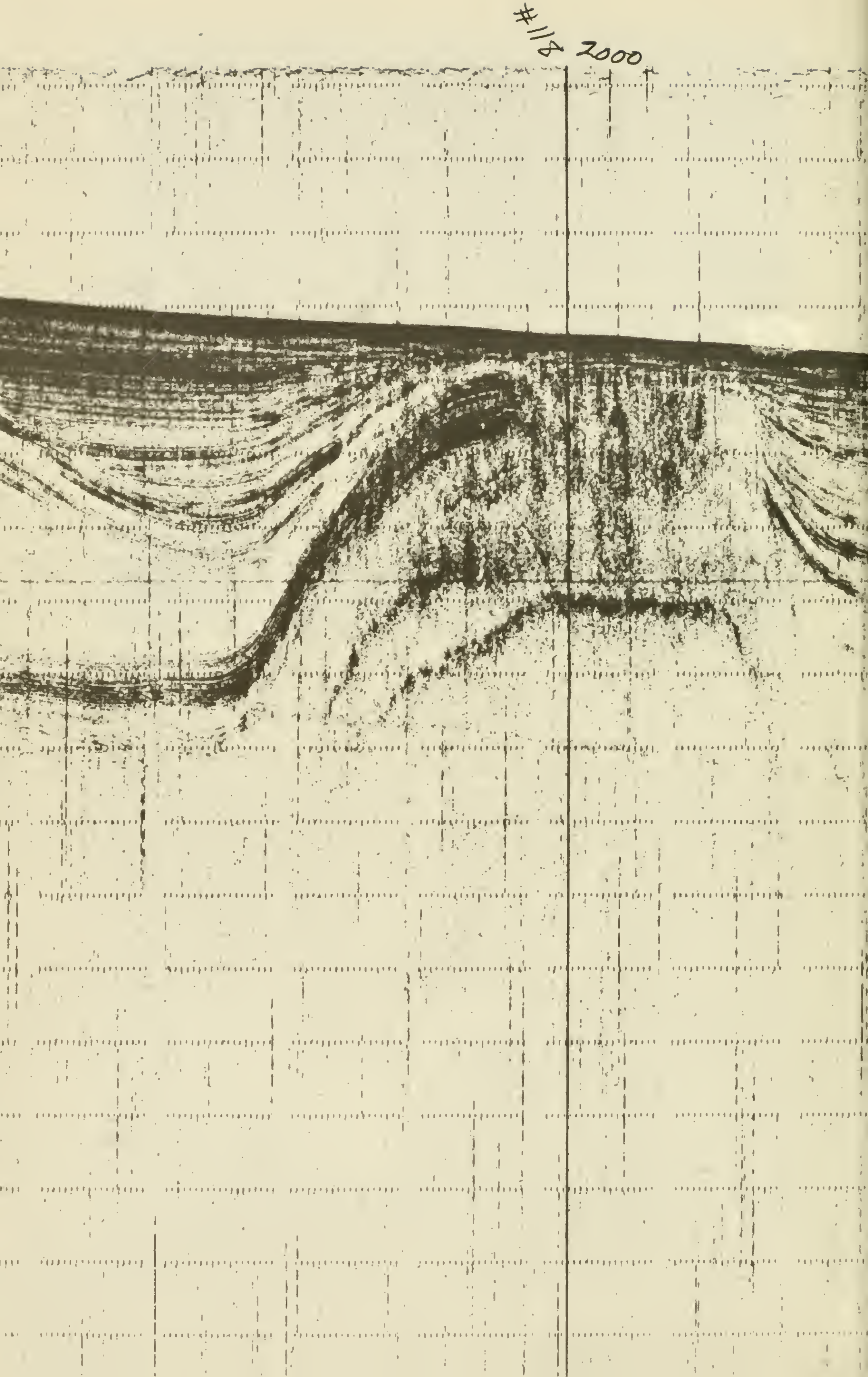
Faced with tasks of this magnitude, the United States clearly must take two steps: First, delineate what parts of the sea are of prime interest and therefore should be given priority attention; and second, increase the speed and efficiency of survey operations.

The first step will involve the assessment of resource exploration and exploitation, transportation, recreation, pollution abatement, defense, and other factors, not solely in the light of what is desirable, but what can be rigorously justified in costs versus predictable benefits. Particular attention must be given to relative priorities of geographical areas, and the time schedules involved in surveying large portions of the ocean. The accuracy and density of data needed must be analyzed, so that all the necessary information is gathered without engaging in the collection of data for its own sake.

The second step will demand broad technological advances, plus a prudent use of our available resources. The Nation must not only operate its vessels

more efficiently, and look toward improved ship types, but also take all possible advantage of other platforms such as submersibles, buoys, aircraft, and spacecraft. A task force recently established by the Council's Committee for Policy Review is currently investigating the general subject of oceanographic ship utilization. It is addressing the desirability of new ship construction, ship inactivations, and interagency use of existing ships, improvements in management, and the preparation of a more systematic approach to the efficient operations of oceanographic ships. Radical improvements of surveying instrumentation also need to be made.

This combination of improved technology and a sharper focus on planning, will enable us to make the most productive use of our time and funds to meet all national goals.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Chapter X

INFORMATION MANAGEMENT

The marine sciences program, reinforced by related scientific and engineering disciplines and technologies, involves numerous institutions, including Federal departments and agencies, State, regional, and international organizations, committees of the Congress, major U.S. industries, and academic institutions. Each of these participants is involved as manager, producer, or user of large quantities of marine-oriented information.

Because of the increased use of the ocean, with new emphasis on the coastal zone, the requirements for data are expanding, especially in the non-Federal area. As larger quantities of data are collected they must be made available to the community in a variety of products on a much faster turnover rate than the present system can accommodate. Data products are also changing in response to the Nation's broader uses of the ocean. The potential of this information does not necessarily lie in the quantity of material collected but in the efficient use and integration of high quality, reliable data for whatever requirement it fulfills for the data-using community.

Obtaining quantitative environmental data needed to support research and operations is an important function of the marine science program. Atmospheric scientists have required more than 100 years to arrive at rational models of our atmosphere and its interactions with land and sea which are useful for short-term and long-range predictions. In contrast, the marine science community has only recently reached a point where scientific research, national requirements, and technology have combined to permit a number of practical and economically significant applications of accumulated knowledge about the sea, coastal zone and Great Lakes.

The marine sciences data networks which support the Nation's present predictive capabilities include agencies, data centers, and academic institutions handling data and other forms of information on the complex physical, chemical, biological variables which characterize the world ocean. One of the major purposes of these networks is to supply real-time data for forecasting purposes. However, it is actually a much broader based group of data- and information-gathering systems. Essentially these systems consist of elements supplying—

(1) Environmental data for real-time and archival purposes;

(2) Nonnumeric information such as bottom photographs, core samples, seismic profiles and biological assemblages;

A successful national ocean program requires the compilation of available data and information—such as this seismic reflection profile of a probable salt dome in the Gulf of Mexico

(3) Bibliographic and documentation information;

(4) Program management and budget information; and

(5) Statistical, economic and demographic information concerning man's oceanic activities.

The ability of a potential user to be able quickly to gather large quantities of information for a specific area in a usable form represents one of the most important functions of a well-managed data system. Table X–1 indicates the problem faced by a data product customer in search of comprehensive information. Eighteen separate national and agency repositories exist which contain 61 individual data bases covering various aspects of oceanographic, estuarine, and limnologic information. However, the existence of particular products or a number of producing agencies does not insure that desired, usable environmental data will be available for any one region.

The process of sorting and integrating information from surveys, research cruises, random ship reports, and operational information from our merchant and military fleets, is continuous at Federal data repositories and producing agencies. However, synthesis of marine environmental data is not complete and the degree to which it must be integrated has not yet been determined. The lack of large blocks of highly correlated information is a particular source of concern to State and local groups, since such information is an important requirement in effective planning for the rational use of marine resources, especially in coastal areas. U.S. data networks should be flexible enough to accommodate not only specific research and operational requirements but the increased number of users who need comprehensive information.

Problems associated with marine environmental data include—

(1) Incomplete identification of the multiple purposes and technical requirements of data collection;

(2) Excessive delays in the "data transmission" system, especially those between collection and availability of data to the marine community as a whole;

(3) Inefficient data collection and handling methods;

(4) Lack of agreement on data handling procedures and standards, which seriously limit data flow among marine science organizations;

(5) Inadequate correlation of data in space and time and lack of selective data retrieval by geographic area, depth or other criteria;

(6) Impending rapid growth in data collection volume arising from expanded airborne, space borne, and surface collection systems with the inevitable impact on the existing overloaded data management system;

(7) The ever-widening gap between the actual state of marine data management activities and the potential activities made possible by technological developments in information handling; and

(8) Lack of a coordinated system of data management from point of collection to ultimate use.

Table X-1—Major Federal Sources for Marine Data [1]

[COE (CERC) = Corps of Engineers (Coastal Engineering Research Center); GLRDC = Great Lakes Regional Data Center; NUC = Naval Undersea Research and Development Center; NWSC = Naval Weather Service Command; FWPCA = Federal Water Pollution Control Administration; SOSC = Smithsonian Oceanographic Sorting Center; ESSA = Environmental Science Services Administration; NESC = National Environmental Satellite Center; NMC = National Meteorological Center; EDS (NWRC) = Environmental Data Service (National Weather Records Center)]

Agency which maintains data base	Physical								Chemical						Geological and geophysical						Biological and fishery												Meteorology				Pollution				Engineering						Other					
																					Population								Experimental																							
	Pressure temperature density	Currents	Tides	Waves	Swell, surf	Drift measurements	Fresh water hiflow/exchange	Mixing parameters	Salinity	Nutrients	Buffer system	Dissolved cases	Radioactivity	Elements	Rock or sediment samples	Rock or sediment descriptions	Elementary processes	Depth	Bottom photographs	Geophysical measurements	Specimen holdings	Tamphonic position	Occurrence and abundance	Primary productivity	Collection data	Migration and movements	Age, growth, and mortality	Fishery statistics	Comparative physiology	Behavior	Population genetics	Endocrinology	Air characteristics	Winds	Clouds	Heat budget	Chemical pollutants	Heat and radioactivity	Microbial pollutants	Other solid wastes	Wave characteristics	Wind forces	Current conditions	Engineering properties of bottom	Sediment transport and coastal erosion	Behavior of materials	Acoustics	Electromagnetics	Optics	Sea ice	Biomedicine	Imagery
National Oceanographic Data Center	X	X	X	X		X			X	X		X				X	X	X	X	X		X	X	X																							X					
World Data Center—A	X	X	X	X	X				X	X		X				X		X		X			X	X									X	X	X												X					
U.S. Army COE (CERC)				X	X																																				X	X	X	X	X							
U.S. Army Lake Survey District:																																																				
GLRDC	X	X	X	X	X		X		X	X	X	X		X				X															X	X			X		X		X	X	X	X	X					X		
U.S. Navy:																																																				
Navoceano	X	X	X	X	X	X	X	X	X	X			X		X	X	X	X	X	X	X		X			X								X				X			X		X	X			X		X	X		X
NUC	X								X																																						X	X		X		
NWSC	X	X	X	X	X	X																											X	X	X	X											X			X		
U.S. Coast Guard	X	X		X	X	X			X	X		X						X	X														X	X	X											X				X	X	
U.S. Geologic Survey							X								X	X	X	X	X	X																																
FWPCA	X						X	X	X	X	X	X	X	X																							X	X	X	X												
Bureau of Commercial Fisheries	X	X							X	X	X	X				X		X			X	X	X		X	X	X	X	X	X	X		X	X	X												X		X			X
SOSC															X	X		X			X	X	X		X	X																										
ESSA:																																																				
Weather Bureau			X	X	X																												X	X	X	X														X		X
Coast and Geodetic Survey	X	X	X	X		X			X			X			X	X		X		X													X	X	X								X									
NESC																																			X	X														X		X
NMC	X			X	X																												X	X	X	X							X							X		
EDS (NWRC)	X			X	X																												X	X	X															X		X
Environmental Research Laboratory	X	X	X	X		X			X	X	X				X	X	X	X	X	X													X	X	X	X																

[1] Derived from System Development Corp. Phase II Report: A National Data Program for the Marine Environment.

Assessment of National Data Management Functions

The Marine Sciences Council, recognizing the need for availability of data and data products, arranged for a comprehensive study to provide a national data program for the marine environment. In establishing the criteria for this study the Council recognized that as national requirements for use of the ocean and its resources begin to expand, new information and products, which will allow the most effective use of the ocean, must be developed in addition to existing products. The study, completed by the System Development Corporation in 1969, sought to identify and forecast data requirements, delineate a national data program and a plan to improve coordination of existing marine data and information service functions, and determine cost estimates for the principal components and alternatives.

The study, entitled "A National Data Program for the Marine Environment," [1] delineates the complex interactions between user groups and the marine sciences data network. The study, which was the second of two contracted by the Council, was performed in a series of interrelated parts. These sections, which were combined into the final report, are—

(1) Analysis of the needs of marine data service customers;

(2) Delineation of priority marine data and products and the analysis of selected data services;

(3) Analysis of data functions; and

(4) National marine data program for the marine environment.

Specifically, the study's major recommendations call for—

(1) Establishment of a permanent mechanism for Federal coordination of marine data management;

(2) Substantial increase in the authority and responsibility assigned to existing national data centers;

(3) Designation of a national ocean engineering data referral center;

(4) Development and maintenance of a comprehensive inventory of marine data holdings, samples, products, and publications;

(5) Strengthening of Federal/State relationships in the acquisition of marine data and the provision of data services;

(6) Completion of the installation of on-board data processing systems on Government oceanographic ships; and

(7) Development of new marine environment data products e.g., sea-air energy exchange forecasts, subsurface current forecasts, inland lakes forecasts, water quality maps and atlases.

In its initial acceptance of the national data program study, the Council's Committee for Policy Review recognized the primary functions of the National Oceanographic Data Center as one of the key elements in the data network. The Committee recommended an expansion and strengthening of the NODC Advisory Board membership so that it may assume the role of

[1] Study performed under contract (N00014–67–C–0559) for the National Council on Marine Resources and Engineering Development by the System Development Corp., Santa Monica, Calif., July 1969.

a permanent mechanism for Federal coordination of the marine sciences data networks. In addition the Committee has asked NODC and its Advisory Board to develop a 5-year time-phased plan, with alternatives, for the improvement of the Center's services, as indicated in specific recommendations within the study, and with other available expert guidance as necessary.

The national data program study, as it relates to the broader problems encountered within the Federal community, is presently the subject of continuing review by the Council and all Federal agencies involved in environmental data management matters.

There are four Federal repositories of environmental data with the primary mission of providing services to the user community: the National Oceanographic Data Center, the Smithsonian Oceanographic Sorting Center (biological and geological sample collections), the National Weather Records Center (marine meteorology), and the Great Lakes Regional Data Center. Funding for services at these centers is indicated in table X–2. Also various data are stored in data banks of individual Federal agencies.

Table X–2—Funding for Marine Data Centers

[In millions of dollars]

Activity	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
National Oceanographic Data Center [1]	1.6	2.1	2.1
National Weather Records Center [2]	0.3	0.3	0.5
Great Lakes Data Center	0.2	0.2	0.3
Smithsonian Oceanographic Sorting Center	0.1	0.1	0.1
Total	2.2	2.7	3.0

[1] Includes NSF contribution of $75,000 in each of the years for World Data Center A.
[2] Supplemented by funds transferred from other agencies for reimbursable projects.

National Oceanographic Data Center

The National Oceanographic Data Center (NODC), Washington, D.C., is an interagency activity established in 1960 under the administrative management of the Naval Oceanographic Office. Policy and technical review are provided by an advisory board with representation from each of the 10 Federal funding agencies and the National Academy of Sciences; representatives of National Oceanographic Instrumentation Center and industry serve as observers. Collocated with World Data Center A for Oceanography, NODC receives, compiles, processes, and preserves oceanographic data from both foreign and domestic sources and disseminates these data to U.S. and foreign organizations and institutions engaged in marine science activities.

During fiscal year 1969, NODC's accomplishments included—

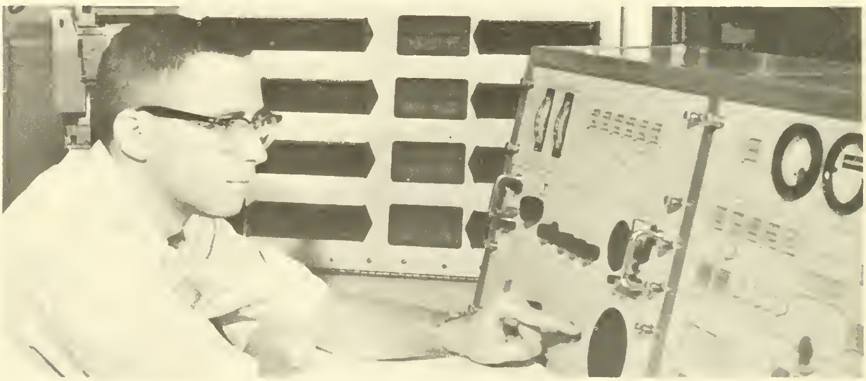
(1) Installation of a third generation computer which will allow for complete automation of major files, thus allowing for faster and more accurate response, as well as a greater variety of products;

(2) Response to an increasing number of requests for data and information (with reimbursable requests up 41 percent over fiscal year 1968, exchange services up 116 percent, and nonreimbursable requests up 20 percent). Table X–3 summarizes the sources of requests;

Table X–3—Sources of Requests[1]—National Oceanographic Data Center, Fiscal Year 1969

	Percent
Federal and State Governments	32
Industry	28
Universities	24
General public	9
Foreign requests	7
Total	100

[1] Total 2,930 requests.



Collection and processing of oceanographic data are rapidly becoming automated. Shown above is the automated data acquisition center for the Shipboard Survey System in the U.S. Navy survey ship Silas Bent. *The primary respository for oceanographic data is the National Oceanographic Data Center. Quality control, information storage and retrieval and analysis are performed by the Center's newly installed computer system.*

(3) Production of a sound velocity atlas for the Eastern Pacific, summarization of mixed layer and thermocline depths (BT data) for various ocean areas, revision of an automated worldwide land-mass data file for more accurate representation of shorelines in graphic displays, production of detailed inventory for a geographically sorted archive of station data;

(4) Initiated development of new data bases including those for sea bed photographs, time series data (buoys), satellite photographs, and for modern, continuously recording instruments such as the salinity-temperature-depth systems. To facilitate receipt of all types of marine data in computer-compatible form (punch card and tape and magnetic tape), completed development of the first phase of a general data system (GDS), and published an instructional guide for use of the system;

(5) Continued cooperation with the World Data Centers in updating of the Intergovernmental Oceanographic Commission's 1963 catalog, "Fixed Oceanographic Stations of the World" (now called "Ocean Data Stations"). This catalog symbolizes the increased emphasis on marine data inventories and directories, which are under development or being planned at both national and international levels;

(6) Continued implementation and expansion of the National Marine Data Inventory (NAMDI) of all marine data and samples generated by U.S. data-gathering activities, for fiscal year 1967–69 operations, and, for selected organizations, from 1960 onward. NAMDI serves not only as a data management tool for U.S. programs but will also act as a prototype inventory for other intergovernmental data exchange programs; and

(7) Accession of 50,000 bathythermograph observations (from eight nations, including the United States), 49,000 oceanographic stations (36,000 from 31 nations, 13,000 from U.S. activities), and varying types and amounts of biological (from 25 foreign and 16 U.S sources) and geological and geophysical (30 foreign and 60 U.S. sources) data and information. These data were incorporated into the national data base for use in the preparation of atlases, in survey planning, environmental studies, and other programs requiring large quantities of data.

During the coming year, NODC's plans include—

(1) Continued development of automated, near-real-time service capability in order to respond to requests for retrieval of data and information including space/time variations of thermocline depth and associated temperature gradients, averages in three dimensions for various physical and chemical marine properties, new computational programs, contouring of descriptive features, and analytical products;

(2) Further development of on-line interactive displays of data and analyses ("live atlas") in order to provide a new and dynamic experimental tool for the researcher as well as a quicker response time to the requester with stringent time requirements;

(3) Continuation of development of a General Data System (GDS) to provide ready acceptance of a wide variety of computer-compatible formats;

(4) Development of a time-series data base to incorporate marine data emanating from national and international data programs;

(5) Preparing a directory of existing marine data, samples, and products—nationally and internationally, and developing specialized inventories, as required;

(6) Continuing use of a time-sharing computer system for inventory and production status control, and expanding inventory information; and

(7) Developing models for use in quality control of data and predictions systems.

Smithsonian Oceanographic Sorting Center

The Smithsonian Oceanographic Sorting Center (SOSC) began its service in 1962. The Center receives, sorts, records, curates, and distributes biological and geological specimens collected by oceanographic expeditions to all seas. Acting as a central processing laboratory, SOSC expedites specimen oriented research analysis by sorting and distributing samples to specialists.

In addition to the biological material handled by the Center, the SOSC geology section acts as a clearinghouse which inventories and distributes geological collections, consisting of sea floor samples, photographs, or general information on rock specimens. Analytic equipment was installed during 1969 to enable optical identification of rock materials, thus assisting in the distribution process. During 1969, SOSC sorted 3,491,589 specimens and distributed 1,148,411 specimens in 531 shipments. The total number of specimens sorted by SOSC since 1963 exceeds 22 million with nearly 8 million specimens distributed.

Responding to the increased interest in environmental quality, SOSC has made arrangements to receive existing unsorted collections from the Great Lakes. The processed specimens will serve as a benchmark for the evaluation of efforts toward pollution abatement and lake restoration (see ch. III).

The National Academy of Sciences is currently studying the possible ecological consequences of a sea-level canal in Panama. In this connection, the Center is prepared to assist in establishing the benchmark collection data necessary to evaluate the effect of unhindered migration between the Atlantic and the Pacific.

Recently, the SOSC has obtained more efficient, modern facilities. An automated records section, first designed in 1966, began full-scale operation with the correlation of specimen data with collection and environmental data from expedition logs; over 50,000 records were produced in fiscal year 1969, many of which represent backlog data from samples previously sorted at the Center.

The Mediterranean Marine Sorting Center operated by the Smithsonian Institution in Tunisia provides a continuing service to U.S. and foreign

scientists and will serve as the sorting center for the Cooperative Investigations of the Mediterranean, a 5-year intergovernmental study starting in 1970, and included in the International Decade of Ocean Exploration (IDOE).

National Weather Records Center

The National Weather Records Center (NWRC), an arm of ESSA's environmental data service, is the archival center for all climatological data gathered by civilian and military agencies. Over 15 percent of the information stored in the Center's tape library contains marine surface observations, including sea surface temperatures and ocean wave data. Marine-related information from over 2,000 merchant ships and smaller fixed stations, such as lightships and ocean station vessels, is used to develop climatological analyses. Volume VIII of the U.S. Navy's global series of Climatic Atlases was completed using the synoptic information collected at the Center. Other forms of information, such as satellite photographs, are also included in the data file. Automation of selected data files now allows limited production of graphic information from data acquired directly from ships.

Great Lakes Regional Data Center

The Great Lakes Regional Data Center (GLRDC), operated by the Lake Survey District, Corps of Engineers, has a program directed toward processing, storage, retrieval, dissemination and analysis of—

(1) Hydraulic and hydrologic data (river flow and water level);
(2) Limnologic data (physical, chemical, and biological);
(3) Hydrometeorological data (precipitation);
(4) Hydrographic data (depth); and
(5) Ice and snow data (formation, movement, break-up and thickness).

Information and analysis services provided by the GLRDC assist in regulating the levels and outflow of Lakes Superior and Ontario, the flow over Niagara Falls, and in the determination of the division of water for hydroelectric power between the United States and Canada. Such data are also used extensively in research on fisheries, pollution, shore processes, currents, and ice formation and movement. The GLRDC acts as a data repository and clearinghouse for data and research projects for the Great Lakes Study Group [1] and the marine-related scientific community in general.

International coordination of data collection and research activities is provided by the GLRDC for the Great Lakes Study Group and in services provided to the International Joint Commission. The GLRDC is a major participant in the International Field Year on the Great Lakes. It main-

[1] The Great Lakes Study Group (GLSG) is an informal organization representing U.S. and Canadian interests, initiated in 1962, to facilitate the exchange of information and to provide informal coordination among the various research activities relating to the Great Lakes and the Great Lakes Basin. This group provides a forum for assisting, coordinating and eliminating duplication associated with research activities on the Great Lakes.

tains liaison with Canadian counterparts for access to data obtained under their programs.

A new computer complex dedicated to an on-line data acquisition system in support of the International Field Year on the Great Lakes is scheduled for installation in the first quarter of fiscal year 1971. The general purpose computer will have the capability for data processing, analysis and storage/retrieval and will be the hub of all systems of the GLRDC. Data will be acquired by a remote system with on-line sensors. This initial use will provide a basis for decentralization to other Great Lakes at the completion of the International Field Year.

Other Repositories

Individual Federal agencies maintain primary centers for their mission related activities. The Department of Defense supports data repositories for geodetic and bathymetric data for nautical charts, and for gravimetric and geomagnetic data. In addition, the Navy's Fleet Numerical Weather Center stores a wide variety of environmental data related to the ocean and atmospheric forecasting in support of operational needs.

Table X–4 indicates the growth of Marine data center files.

Table X–4—Growth of Selected Oceanographic and Marine Meteorological Observations

National Oceanographic Data Center (Cumulative Acquisitions)

Data type	1965	1965	1967	1968	1969
Bathythermograph analog data	700, 000	739, 000	760, 000	783, 000	800, 000
Bathythermograph digital data	114, 000	199, 000	292, 000	309, 000	500, 000
Station data	239, 000	270, 000	305, 000	329, 000	355, 000

National Weather Records Center (Yearly Acquisitions)

Marine meteorological data—Cooperative ship program	487, 200	422, 530	574, 654	568, 222	[1] 625, 000
Bilateral agreements		939, 000	875, 000	875, 000	[1] 962, 000
International exchange	122, 934	351, 979	176, 159	344, 341	[1] 378, 000

Smithsonian Oceanographic Sorting Center (Yearly Acquisitions)

Samples:					
Received	15, 834	5, 207	7, 281	3, 427	2, 927
Sorted	3, 266	3, 999	4, 053	3, 263	1, 972
Specimens:					
Sorted	4, 973, 438	3, 397, 692	6, 885, 141	3, 483, 181	3, 491, 589
Shipped	915, 668	3, 636, 005	989, 595	910, 057	1, 148, 411

Great Lakes Regional Data Center (Cumulative Observations)

Data type	1965	1965	1967	1968	1969
Water level readings (station months [2])	53, 660	54, 320	54, 980	55, 640	56, 300
Wave data (station months [3])	240	280	320	360	400
Ice and snow:					
Visual (station months)	588	636	684	732	780
Aerial (synoptic charts [4])	250	260	270	280	290
Water temperature (station months)	1, 572	1, 644	1, 716	1, 788	1, 860
Hydrographic data (field sheets)	670	690	710	730	750
Shore based hydro-meteorological data [5] (station months)	122	134	146	158	170
Shipboard hydro-meteorological data [5] (station months)	36	42	48	54	60
Water characteristics [6] (samples)	263, 000	276, 000	289, 000	302, 000	315, 000

[1] Estimated.
[2] Filed in hourly readings. (Total information bits=station months times 24 hours times 30 days.)
[3] Continuous records.
[4] Includes thickness, coverage and topographic features for all 5 lakes.
[5] Includes air and water temperature, wind direction and velocity, current direction and velocity from multilevel sensors.
[6] Includes multicomponent chemical analyses and physical properties.

By receiving data from a variety of sources the Fleet Numerical Weather Center (FNWC) is able to provide forecasts and analyses for fleet use, and some of this information is useful to the fishing industry and for general meteorological forecasting. The computer complex at Monterey, Calif., handles over 25 million data bits a day to provide services through the Navy's environmental data network, and the FNWC serves as a center for an environmental forecasting program which covers the Northern Hemisphere. In addition, FNWC is responsible for the majority of the Navy's numerical environmental prediction program and as such plays a key role in developing prediction products for the fleet.

In the Department of the Interior, environmental data are collected and utilized by a number of bureaus. The Geological Survey itself compiles data on stream discharge measurements, chemical and related water quality data. The STORET system created by the Federal Water Pollution Control Administration maintains hydrological, meteorological, physical, chemical, biological and other data related to water quality and water quality management. Operating through its 16 regional laboratories and its statistics branch in Washington, D.C., the Bureau of Commercial Fisheries collects and publishes data on physical, biological, chemical, geological, and acoustical oceanography, as well as commercial fish catches.

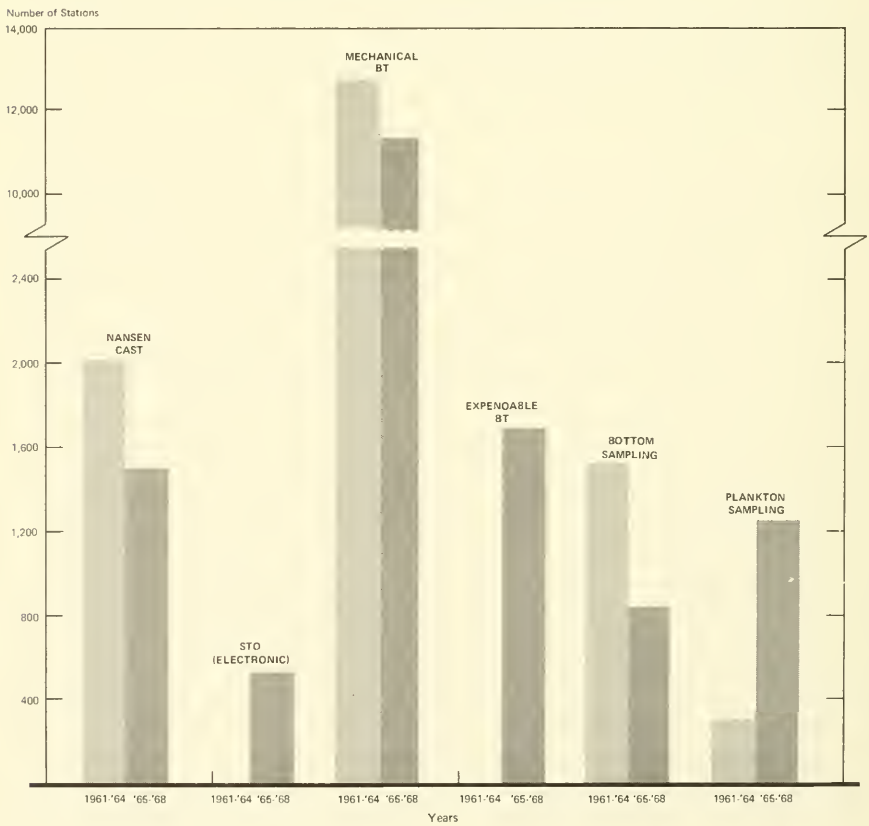
The Department of Transportation through the oceanographic work of the U.S. Coast Guard provides 34 percent of the U.S. station data processed by NODC during fiscal year 1969.

In addition to the Federal agencies mentioned and the four Federal data centers, the Nation's major oceanographic institutions maintain data holdings which contribute to the national marine data inventory of all data and samples generated by U.S. data gathering activities. An example of the use of NODC's NAMDI to identify data collection trends is illustrated in figure X–1 which shows the time distribution of selected measurements taken by the Woods Hole Oceanographic Institution over the past 8 years.

Employing Data Internationally

The programs and projects of the International Decade of Ocean Exploration will lead to the production of diversified types and large quantities of marine data and samples. Rapid and economical flow of these data among universities, Government activities, industry, and data centers is required to assist in the effective and timely realization of IDOE objectives. Also these data will be the principal currency for cooperation among participating nations.

Figure X–1—Trends in Observational Programs of the Woods Hole Oceanographic Institution, 1961–68



* BASED ON REPORTS IN THE NATIONAL MARINE DATA INVENTORY (NAMDI)

The Intergovernmental Oceanographic Commission has identified a number of problems related to international sharing of data on the marine environment, including—

(1) Improvement and consolidation of bibliographic and related information services;

(2) Early exchange of plans and preliminary results of observational programs;

(3) Integration of real-time exchange of oceanographic data with the meteorological system;

(4) Development of methods for storage and retrieval of biological, geological and geophysical data;

(5) Automation of international data banks and improved programs and methods for making their contents available;

(6) Development of standardized and/or computer-compatible data formats;

(7) Timely establishment or improvement of international inventories of ocean data and samples and provision for centralized cataloging of sea data available from various private and public sources; and

(8) Strengthening the system of sorting centers for biological material.

Neither national nor international capabilities are adequate to facilitate the exchange of the ever-increasing diversity and volumes of marine data being generated by many nations. In preparation for the projects of the IDOE, certain activities must be launched now to allow for effective utilization of the platforms and scientists as well as for distribution and analysis of the data. This preplanning takes on several aspects, each dependent on supporting actions of national and international data centers. Among these are the—

(1) Development of national and international directories of holdings, and inventories of ongoing collection efforts;

(2) Evaluation of kinds of data products to be developed from IDOE projects including atlases and computerized display systems;

(3) Processing of data collected from foreign sources that bear on new project areas;

(4) Extensive surveys of research literature covering selected IDOE areas; and

(5) Establishment of communication links between data centers, scientists, and computers.

NODC is now planning for implementation of its role in the IDOE with the National Science Foundation which has lead agency responsibility for the program. Also the Center will serve as the regional data center for the Cooperative Investigations of the Caribbean and Adjacent Regions (CICAR). In a similar action, the Smithsonian Oceanographic Sorting Center is preparing to make its facilities available so that sorting activities can be done by trained technicians thus freeing scientific personnel for more direct participation in the analysis of the samples collected from IDOE expeditions.

Chapter XI

FURTHERING MARINE SCIENCE RESEARCH AND MANPOWER

In the prologue to "An Oceanic Quest" [1] the National Academy of Sciences and the National Academy of Engineering recommend these objectives for future U.S. marine research programs to be performed during the International Decade of Ocean Exploration: "To achieve more comprehensive knowledge of ocean characteristics and their changes and more profound understanding of oceanic processes for the purpose of more effective utilization of the ocean and its resources." In its report, "Our Nation and the Sea," the Commission on Marine Science, Engineering and Resources recommended that "The Nation should establish as a major goal the advancement of an understanding of the planetary oceans as a principal focus for its future basic marine science effort."

Both recommendations suggest the importance of fundamental and applied oceanographic research to the attainment of better understanding and of more rational use of the seas. In an attempt to turn the results of the national marine research program to best advantage, there has been, over the past decade, a concerted effort on the part of the Federal agencies to develop and foster programs of broad basic research which would ultimately enhance the future use of the world ocean.

Dimensions and Nature of Research

Scientific research, in its broadest aspects, has been the supporting structure that has allowed the present national ocean program to flourish and expand to meet significant, current marine-related problems. Although large-scale cooperative experiments are necessary for establishing and verifying phenomena on a planetary scale, only thoughtful study and research by individual investigators make these possible.

The value of most research is not time limited. Usefulness of data, although they may decay in their absolute value, carries on as a foundation for future work or as a basis for more applied activities. Excellence in content and method is insurance that basic studies will serve as keystones in

[1] "An Oceanic Quest: The International Decade of Ocean Exploration," an appraisal of the Decade prepared for the Marine Sciences Council by the National Academy of Sciences and the National Academy of Engineering, 1969.

If we are to understand, predict the behavior of and use the marine environment we must employ basic marine research. Here, an investigator studies coral-destroying "Crown of Thorns" Starfish in the Pacific.

research. Perhaps the most notable example is that of the samples and information gathered from the *Challenger* Expedition (1872–76) which are still being examined and compared with contemporary studies.

The marine sciences are multidisciplinary; marine scientists apply the fundamental disciplines of physics, chemistry, and mathematics as well as biology, astronomy, geology, and meteorology to their study of the world ocean.

Influenced by the rotation of the earth, imbalance in solar heating, and interactions with the atmosphere, the world ocean acts as a large moderating system. But the ocean is not homogeneous; various physical and chemical processes act on it to bring out differences in water masses and natural fertility. Boundary conditions imposed by continental masses and undersea topography mold the contemporary conditions within the ocean basins.

As in other environmentally dependent disciplines, single solutions to a problem are never without relation to other causes or effects. Perhaps the geologic concept of "multiple working hypotheses" is an apt description of the nature of the present research endeavor in the marine sciences. But a multiple hypothesis approach implies a number of investigators and investigations, some operating on a small laboratory scale, others on collection and synthesis of information for the solution of global problems.

The investigations and some highlights of last year's work, presented in this chapter, are noteworthy examples of the nature of the marine sciences program—a blend of many problems and workers, each contributing to our understanding of the world ocean.

Arctic and Northern Cold Regions

The development of the Arctic and its adjoining areas often involves finding unique solutions to complex problems. It has become apparent, for example, that vast quantities of natural resources await us, yet in terms of exploration the area is extremely inhospitable. The environment is still largely unpolluted, although pollutants could persist for unusual lengths of time. The shortest routes between many world centers cross Arctic lands and waters, yet routine, scheduled commercial marine transportation through the Arctic region still lies far in the future. Strategically, the Arctic is of great importance but its environment precludes conventional surface naval operations and greatly changes the nature of most other military actions.

Because of the Arctic's overall significance and resource potential Arctic environmental research was one of the five initiatives selected by the President for immediate, priority attention. Major objectives of the Arctic programs will be—

(1) Investigations of the polar icepack, including its effect on transportation and global weather; its interaction with coastal installations and morphology of the coastline; and its impact on sedimentation processes and coastal ecology;

(2) Study of the polar magnetic field and its effect on communications;

(3) Investigations of geological structures underlying the Arctic lands and polar seas as both potential mineral sites and hazards to construction and resource development;

(4) Comprehending the balance of the Arctic ecosystem; and

(5) Experiments on the degradation of liquid and solid wastes under Arctic conditions.

Man's psychological and physiological capacities to adapt to this inhospitable environment also will receive increased attention. Consideration will also be directed to formulating an overall policy framework for Arctic-related activities.

In support of this initiative and in view of the recent surge of commercial activity in the Arctic and their continuing mission objectives 11 Federal agencies are planning to expand or mount efforts of varied scope and intensity in fields including engineering, meteorological and environmental research, resource assessment and development, health and welfare, and Arctic transportation. The National Science Foundation has been given the lead agency responsibility for Arctic research programs. Of the $2 million requested for new Arctic programs by NSF in support of the Arctic initiative, $0.8 million would be funded for marine related activities. Federal funding for Arctic environmental research is shown in table XI–1.

Table XI–1—Federal Research on Arctic Phenomena [1]

[In thousands of dollars]

Estimated fiscal year 1971 funding	Ice-pack	Magnetic field	Geologic structures	Ecological balance	Perma frost	Waste degradation	Human behavior and physiology	Other	Totals
Department of Agriculture				91.0				273.3	364.3
Department of the Air Force		913							913.0
Department of the Army	9	58	24	56.0	34	90		930.0	1,201.0
Department of Commerce		215							215.0
Department of Health, Education, and Welfare						63	214	1,223.2	1,500.2
Department of the Interior			893	93.6	464	250		2,000.0	3,700.6
Department of the Navy	1,583	25	220	95.0	40	80	35	2,667.0	4,745.0
Department of Transportation	500							100.0	600.0
Atomic Energy Commission			740	567.5	95			1,869.0	3,271.5
National Aeronautics and Space Administration	324	713		350.0	80				1,467.0
National Science Foundation	800	1,300	500	500.0	200		130	820.0	4,250.0
Totals	3,216	3,224	2,377	1,753.1	913	483	379	9,882.5	22,227.6

[1] This compilation is broader than marine sciences. Marine-related Arctic research will total approximately $8 million in FY 1971.

In 1969, the Corps of Engineers through its Cold Regions Research and Engineering Laboratory pursued its program of studies into ice mechanics, including ice forces on marine structures and ships, investigation into tech-

niques of channel and harbor construction and maintenance, physics and chemistry of frozen ground and construction on permafrost and in offshore ice-bound coasts. Consideration was given to the use of ice as a construction material. In addition, the Corps provided technical advice during the *Manhattan*'s transit of the Northwest Passage.

The Coast and Geodetic Survey carried out coastal surveys of Alaska, including Norton Sound and Cook Inlet, and acquired information needed for development of a marine terminal at Anchorage; several standard nautical charts, bathymetric maps with geophysical overlays were also published for the Norton Sound area. In addition, a marine forecast center was established by ESSA at Anchorage to provide daily forecasts on weather, waves, temperature, visibility, and ice conditions.

The Navy continued its Project Birdseye long-range ice observation and study program, covering much of the Arctic Basin at monthly intervals. Ice observations and forecasts were provided for several users, including the *Manhattan*'s transit, as well as for military Arctic resupply operations. Ice Island T–3, a passively drifting platform, carrying a multidisciplinary group of scientists, funded through Navy programs, provided much new knowledge of geophysical, oceanographic, cryological, and meteorological environmental relationships of the Arctic Basin. The Naval Arctic Research Laboratory staff and associated scientists provided advice, guidance, and services to Government and private industry in numerous problems related to production and transportation of oil on the North Slope of Alaska. The Navy conducted submarine under-ice operations in which Navy scientists participated.

A major investigation of western Greenland glaciers and oceanographic conditions was conducted by the Coast Guard to determine if the iceberg productivity patterns of Greenland glaciers have changed markedly. Testing of several techniques for improved sea ice observing and forecasting included Navy's use of ruby lasers to obtain detailed sea ice profiles, as well as estimates of roughness and surface reflectivity, and the Coast Guard's use of a side-looking airborne radar for iceberg and pack ice observations, which provided direct support to the *Manhattan*.

Other Arctic programs involved—

(1) Geophysical experiments including bottom-mounted seismometry carried out by the Advanced Research Projects Agency (ARPA) of the Department of Defense in the Aleutian Island area, leading to a more thorough understanding of the geology and geophysical structures of this island and trench complex;

(2) Development by ARPA of an Arctic surface effects vehicle as a principal goal, looking both toward military and commercial needs;

(3) Development by Navy laboratory and university contract scientists of a design for a large scale experiment on sea ice dynamics—Project AIDJEX. ASW hydroacoustic and thermal microstructure experiments are being developed as goals to be completed during the spring of 1970 from two manned and one instrumented, unmanned ice floe stations in the Arctic Ocean;

(4) A cooperative U.S. Navy/Canadian program of 15 dives by submersible to depths over 1,500 feet in the Canadian Archipelago in which geological, biological, and acoustical data were obtained;

(5) Development by the Navy of a computer-based model which relates environmental data to the prediction of sea ice growth and decay;

(6) Oceanographic surveys of the Bering, Chukchi, and Beaufort Seas, as well as of other significant areas, continued by the U.S. Coast Guard, the U.S. Navy and U.S. Geological Survey;

(7) A major study by the Coast Guard of polar transportation requirements, leading to the design of a five-year research program for which field work has already commenced with studies of sea ice along the Alaskan coast;

(8) Bottom sampling and seismic profiling by the U.S. Geological Survey in the northern Bering Sea with emphasis on heavy metal deposits and areas of petroleum potential; and

(9) ESSA research programs including study of the solar-geophysical relationships and their related telecommunications effects. Investigations encompass such areas as measurements of auroral air-glow and the anomalous effect on the geomagnetic field in the Arctic region.

Ecological Shifts in the Environment

Over the past decade, as research and survey operations have broadened the scope of knowledge about the marine environment, scientists have become aware of more subtle ecological shifts, both biological and physical. In some cases, such as the balance between anchovy and sardine populations, programs of scientific observation and conservation have attempted to restore the balance between these species—thereby improving their economic potential. In other cases, where unexplained changes in water temperature or nutrient supply stimulate planktonic forms and cause toxic effects such as the "Red Tide," attempts thus far to alter the ecological environment have not been successful since direct intervention in the situation is too costly or the resulting effect on the environment speculative.

An example which will require further study is that of the appearance of a predatory starfish, *Acanthaster planci,* commonly called the "Crown of Thorns," in the U.S. Trust Territory, the Hawaiian and Marshall Islands group and off Australia. Its normal ecological position in past years has been that of a minor predator of coralline invertebrates, primarily those which live in coral reefs. During 1969 there were reports of widespread destruction of reef material by an influx of these starfish. Because this was an abnormal condition which might have serious consequences to reef ecologies, several agencies—the Department of the Interior, the U.S. Navy, the U.S. Coast Guard, the Smithsonian Institution and the National Science Foundation, have initiated studies of the affected areas. Although complete surveys of all island areas were not made a recent report points out that the starfish infestations are of serious growing proportions in some areas.

Some of the direct consequences of this change in ecological balance relates to man's use of the areas under attack by *Acanthaster planci*. Reefs and atolls are havens for numerous fish species and are zones of high organic productivity. Destruction of the coral material of the reefs would upset the productivity of the reef, especially the productivity of fish useful to the local inhabitants.

Understanding of the long-term effects of the predatory action of the "Crown of Thorns" is still rudimentary. For this reason, the Department of the Interior is examining the results of several independent reports [1a] in order to formulate further research into the nature of the infestations and future action in controlling or modifying the destruction of these important natural resources.

Global Deep Drilling Investigations

An outstanding example of a major U.S. research program, which relates to a global research problem, is the National Science Foundation's ocean sediment coring program.[2] Recovery of cores from areas where the water depths are over 20,000 feet has demonstrated the great potential of the drilling ship *Glomar Challenger*. By determining the ages of the oldest sedimentary material in the cores the validity of the sea-floor spreading concept can be tested—if the continents are drifting apart, the sea floor sediments should be progressively younger in age near the proposed central area from which tectonic motion emanates. Preliminary shipboard examination of the samples indicated that this systematic shift in the age of sediments does occur, lending support to this hypothesis. A reconstruction of the opening and formation of the Atlantic Ocean is now possible as a result of the direct evidence recovered by deep sea drilling.

Other signal discoveries from early examination of the corings have shown that the rates of sedimentation in the deep ocean basins vary with time and location by orders of magnitude. Corings taken in the Gulf of Mexico from the Sigsbee Knolls and related buried structures of the deeper portions of the Gulf revealed that these formations consisted of salt diapirs having associated hydrocarbon deposits.

Since much of our previous information concerning the igneous and sedimentary material of the ocean bottom was inferred from indirect seismic methods, the recovery of in situ rocks has answered questions of interpretation of geophysical information. However, the drilling has also opened up a multitude of problems relating to sequences of deeper sediments not heretofore predicted from analyses of previous oceanographic and geophysical sediments.

[1a] "*Acanthaster planci*—Impact on Pacific Coral Reefs," final report to U.S. Department of the Interior, Research Laboratories, Westinghouse Electric Corp., Pittsburgh, Pa., October 1969. ("Crown of Thorns" Workshop, University of California, San Diego, Scripps Institution of Oceanography, October 1969.)

[2] Plans for the ocean sediment coring program were described in the Marine Sciences Council's third annual report, "Marine Science Affairs—A Year of Broadened Participation."

Future scientific plans in the Deep Sea Drilling Project of the ocean sediment coring program are based on the geophysical patterns developed as a result of nearly 1 million miles of traverses conducted over the past two decades. Global patterns of gravity, magnetic and thermal anomalies, along with information about the composition, thickness and stratification of the sedimentary cover of the deep-sea and continental margins allow for the selection of drilling sites to verify and expand knowledge about specific geophysical characteristics. Hypotheses about major tectonic processes, long in scientific controversy, can be tested by a well-planned sampling program for the deep-sea and continental margins.

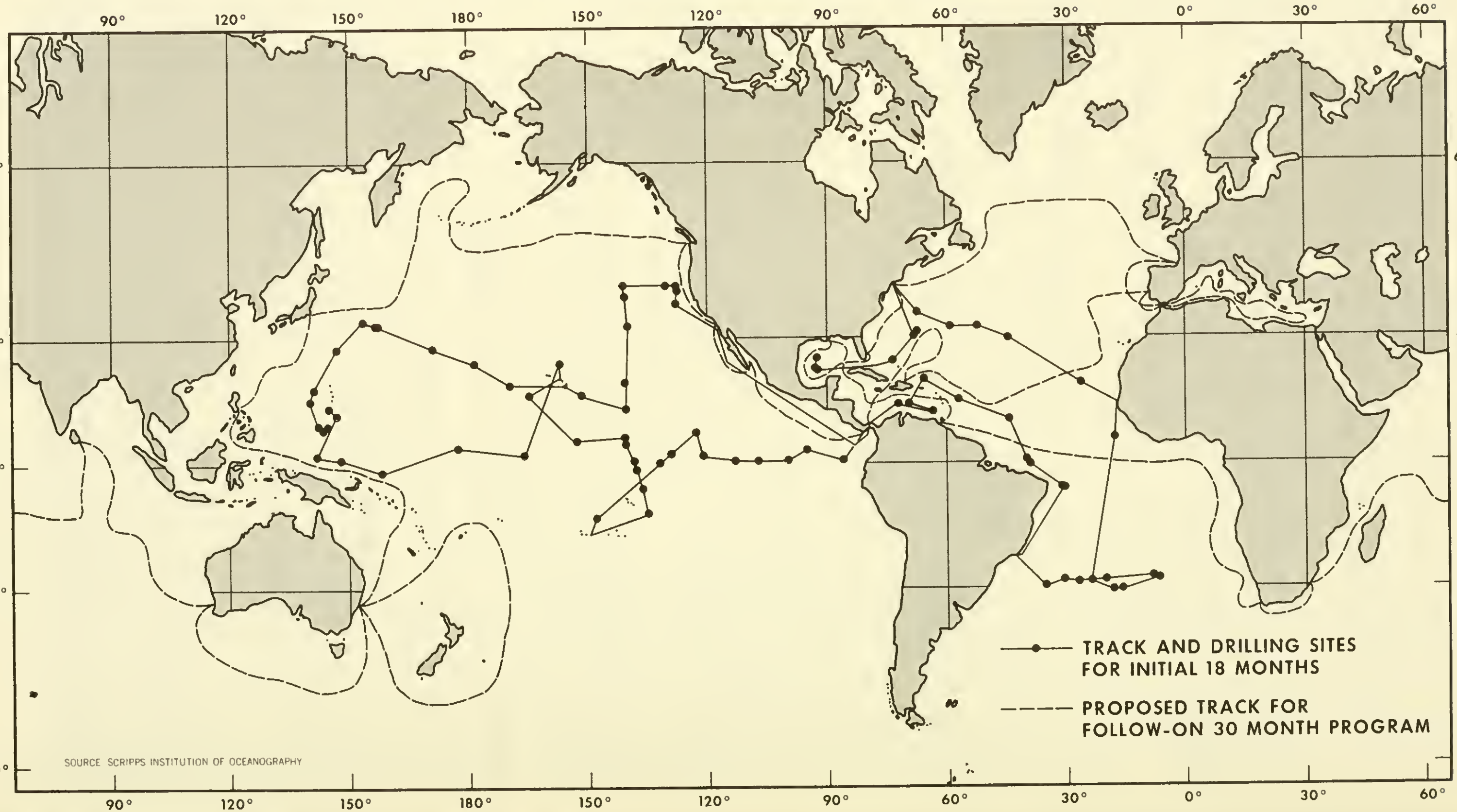
Based on the analysis of these patterns and the need to validate a number of geophysical hypotheses, drilling is scheduled for continental margins of the major ocean basins, the Gulf of Mexico and selected sites of tectonic and sedimentary significance. Transition zones between the continents and the deep ocean basins will also be sampled to develop a better understanding of their history and relevance to global tectonics. Reconnaissance of the Indian Ocean and Mediterranean Sea, and additional drilling in the Atlantic and Pacific Oceans will be undertaken in the near future. The tracks and drilling sites for the completed and proposed deep sea drilling project are illustrated in figure XI–1.

The drilling system of the *Glomar Challenger* will be modified to extend its capabilities. Drilling innovations such as reentry of the borehole with drill pipe; a down-hole drilling motor; new instrumentation to monitor down-hole operations; drill or core bits with replaceable cutting elements; and other system improvements will be considered and possibly tested as the program progresses. The ocean sediment coring program is producing, from both a technical and scientific standpoint, results of benefit to the scientific and industrial communities and providing valuable information on deep-sea drilling technology for future industrial use.

Determining the Energy of the Environment

The coupling between the atmosphere and ocean systems has been of interest to oceanographers and marine meteorologists, especially as it affects basic atmospheric circulation and the exchange of energy, water, gases, and particulates at the sea-air interface. In carrying out its responsibility as lead agency for sea-air interaction studies, ESSA coordinated the scientific program and logistical support for an experiment to study the exchange of energy between the ocean and atmosphere and the vertical and horizontal spreading of these energies within each fluid. Seven Federal agencies, 22 universities and independent laboratories, and six industrial organizations participated in the experiment. In all, an expedition consisting of 12 ships and 28 aircraft, and 1500 scientists and technicians performed over 100 experiments within the 90,000 square mile field area. Termed the Barbados Oceanographic and Meteorological Experiment (BOMEX), field operations

Figure XI-1—Deep Sea Drilling Project Track



were conducted in the oceanic areas of the equatorial Atlantic off the Island of Barbados.[3]

One of the most difficult problems in mounting a medium scale oceanographic experiment is the coordination of large numbers of platforms and sensors required for time-synchronous measurements of fluxes, momentum, and other variables. Because of the nature of its design and the large number of participants, simultaneous measurements from levels below the mixed layer in the oceans to 60,000 feet could be taken, thus allowing for a comprehensive characterization of the physical environment in the BOMEX area.

The principal objectives of the BOMEX program were—

(1) Determination of the flux of energy from the ocean to the atmosphere—the sea-air interaction;

(2) Investigation of the dynamics and structures of the mixed layer in the upper ocean;

(3) Exploration of large convective systems over the tropical Atlantic;

(4) Determination of the radiation budget over the BOMEX area from the ocean surface to the top of the atmosphere; and

(5) Provision, by use of satellites, of scientific background information for BOMEX projects for comparison with actual direct measurements from other platforms, and for communication experiments with aircraft and ships for future global and ocean systems.

The BOMEX program was divided into several data-gathering phases; two methods were used. Initially, the point method measured the upward and downward flow of energy in both sea and air at specific points on the sea surface. The second, or volume method, treated the BOMEX area as a cube. In concentrated observation periods of approximately 4 days each, conditions in the BOMEX area were measured by instrumented balloons, by instruments dropped from aircraft, by the ships at the corners of the array, and by day and night "line integral" flights around the cube's outer perimeter. These measurements will be used to calculate the net gains or losses in heat, moisture, and wind energy in the volume of air overlying the BOMEX square, and the amount of heat and moisture that the atmosphere over the area receives from the sea.

The fourth data-gathering period was devoted to the exploration of convective systems. It is in these systems that most of the energy in the atmospheric boundary layer is transported to higher levels and distributed throughout the troposphere. The choice of the areas was determined from cloud photographs taken by ESSA satellites and the NASA ATS–III synchronous satellite.

The volume of data taken during the full BOMEX project is prodigious. Analysis and correlation of the information taken from instrumentated aircraft alone amounts to 4,000 hours of continuously recorded observations of a variety of weather elements. Because of the enormous amount of data to be reduced and correlated it is estimated that the major data elements

[3] Federal participation in BOMEX included AEC, BCF, ESSA, NASA, Navy, Air Force, Coast Guard and Geological Survey.

will not be reduced before mid-1970. However, preliminary analysis of certain data have revealed—

(1) Strong eastward-moving currents in the Atlantic off Barbados, where ocean atlases show predominantly westward flow;

(2) A large water mass, probably from the Amazon River, that remains unmixed with ocean water as far as 1,000 miles from its source;

(3) The presence of small atmospheric "fronts" 3 to 4 miles long, with sudden temperature and humidity increases often followed by a rapid temperature drop, while the humidity decreases slowly over a period of 10 minutes—suggesting the existence of patches of moist and dry air a mile or more in diameter with little change in temperature; and

(4) Twice as much incoming solar radiation being absorbed in the tropical atmosphere as had been believed—indicating that the amount of solar radiation available to heat the oceans is less than previously estimated.

BOMEX follows closely the recommendations of the Joint Panel on Sea-Air Interaction and the Panel on International Meteorological Cooperation of the National Academy of Sciences (1962). These panels pinpointed the problem of sea-air interaction as one of the most important, but also most difficult research problems of our time, requiring the close cooperation of the atmospheric and oceanographic scientific communities. Such cooperation has been achieved in BOMEX.

Understanding Ocean Properties Through Research

During the past year a number of significant discoveries have been made at the oceanographic institutions and at various marine science departments which have increased our basic understanding of the living and nonliving properties of the ocean. Generally these are contributions of individual scientists to develop hypotheses concerning the ocean, its contents, boundaries, interactions and evolution.

Extremely sensitive instruments were used to detect the presence of 10 radionuclides in the ocean down to 1,500 meters.[4] Specific activities of zinc-65 and cobalt-60 detected in marine organisms were several orders of magnitude higher than sea water probably indicating that the chemical and physical forms of radionuclides are selectively concentrated, especially in the differential chemical absorption among certain invertebrates.

Continued investigations into the major geological structures of the central North Pacific have significantly advanced the development of theories of sea floor spreading and plate tectonics.[5] Studies of bathymetric and mag-

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[4] Robertson, D. E., Ranscitelli, L. A., and R. W. Perkins; "Multi-element Analysis of Sea Water, Marine Organisms and Sediments by Neutron Activation without Chemical Separation," Proceedings of International Symposium on the Applications of Neutron Activation Analysis in Oceanography, Brussels, June 1968.

[5] Peter, G., Erickson, B. H., P. J. Grim; "Magnetic Structure of the Aleutian and Northeast Pacific Basin," *The Sea,* vol. 4, Interscience Press, 1969.

netic data have shown not only that the major East Pacific Fracture Zones extend westward to at least longitude 180° but that there was a marked change in the direction of sea floor spreading during the early Cretaceous.

Studies of portions of sea floor in the central North Pacific which are considerably removed from active spreading centers indicate that abyssal hill topography reflects the original grain imparted to the crust during its formation.[6] This new line of study on abyssal topography may prove a useful approach to investigations of sea floor spreading.

Analysis of measurements made from the Office of Naval Research Drift Station ARLIS–II in Denmark Strait revealed a temperature disturbance in the sediments corresponding to change in ocean-botton temperature of the order of 0.1° C. occurring several hours to a month prior to the observations.[7] The results suggest that a surge of cold bottom water (−0.45° C.), 100 km. in horizontal extent, spilled over the Greenland-Iceland Ridge into the North Atlantic in April 1965. Details of such fluctuations and their controlling mechanisms are poorly understood because of the difficulty of obtaining synoptic coverage of conventional hydrographic observations. "Memory of the Mud" provides a means of reconstructing the synoptic picture.

Strength tests of in-place material on the sea bottom indicate that the strength of sedimentary material may be two to three times the strength as measured from core samples.[8] This may open new lines of investigation of the diagenetic effects on sedimentary materials at depth.

Investigations are underway to determine the effect on the ecology of sea life of material which may be brought into the water column in the form of fine grained sediments during marine mining operations.[9] It is possible during marine mining operations that these sediments and nutrients brought from depth may harm the existing life or the presence of higher concentrations of nutrients may be of benefit to most life forms.

The mechanism of absorption by the oceans of the excess atmospheric CO_2 from the burning of fossil fuels has been studied by scientists from a number of universities.[10] The utilization of CO_2 by marine plants also affects the air-sea CO_2 exchange, but findings indicate that low CO_2 pressure regions produced by phytoplankton activities do not necessarily mean that vigorous air to sea invasion of CO_2 will take place. It appears that the surface film of organic matter produced by phytoplankton over the sea surface can retard the invasion.

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[6] Grim, P. J., and R. P. Naugler; "A Fossil Deep Sea Channel on the Aleutian Abyssal Plain," *Science*, vol. 163, p. 3839, 1969.

[7] Lachenbruch, A. H., and B. V. Marshall, 1968. Heat Flow and Water Temperature Fluctuations in the Denmark Strait. Jour. Geoph. Res. 73 (18): 5829–5842.

[8] Keller, G. H.; "Shear Strength and Other Physical Properties of Sediments from Some Ocean Basins," Proceedings ASCE Symposium, "Civil Engineering in the Oceans," pp. 391–419, 1967.

[9] Keeling, C. D., "Carbon Dioxide in Surface Ocean Water—For the Global Distribution of Partial Pressure," Journal of Geophysical Research, vol. 73, pp. 4543–4553, 1968.

[10] Park, K., Curl, H. C., and W. A. Glooschenko, "Carbon Dioxide Anomalies in the North Pacific Ocean," Nature, vol. 215, pp. 380–381, 1967.

Preliminary experiments with the annual jellyfish *Aurelia* show that animals in the laboratory do not die synchronously in the summer as previously assumed but can be maintained alive for at least seven additional months in laboratory aquaria.[11] By controlling the animals' environment it is hoped that individuals can be induced to perpetuate individual longevity almost indefinitely. In this system, size, time and sexual maturity can be separated as prime variables for an analysis of senescence for the first time in a large, easily handled laboratory animal.

Phytoplankton have long been assumed to remain within the lighted surface layers of the ocean as a result of morphological and chemical modifications of the cell.[12] However, it has now been demonstrated that the sinking rates of these plants fall within the speed- and wind-induced, small scale circulation processes, indicating that the turbulent motion of the sea can adequately account for phytoplankton flotation.

It has been demonstrated that phytoplankton growth is prohibited or prevented in waters over New York City's sewage dumping area.[13] The toxicity is increased by the addition of small amounts of trace metals and is partially decreased by the addition of metal chelators indicating the toxicity results of high concentrations of toxic metals in the sewage sludge.

The relationship of changes in the earth's magnetic polarity to other phenomena in evidence from the study of piston cores from the Antarctic shows a strong relationship between changes in the earth's magnetic polarity and earthquakes,[14] volcanism, climatic changes, evolution and faunal extinction. There appears to be a direct correlation between these phenomena.

There are now positive indications that major falls of tektites are related to changes in the polarity of the earth's magnetism.[15] Present work is concentrating on determining the frequency, causes, rates of change, and prediction of future changes of these natural phenomena with reference to environmental planning and hazards to mankind from the environment.

Sediment cores obtained from Drift Station T–3 have been analyzed with respect to geological, geophysical, biological and climatic history as well as physical properties important to hydroacoustics applications.[16] Utilizing established times of reversals of the earth's magnetic field strata in Arctic cores have been dated and sedimentation rates established at 1.2.6 mm/1000 years during the last 4 million years. On the basis of analyses of inorganic

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[11] Hamner, William G., Unpublished results from progress report on NSF grant GB–13663 to the University of California, Davis, 1969.

[12] Smayda, Theodore J., "On the Suspension and Sinking of Phytoplankton in the Sea," Annual Review of Oceanography and Marine Biology, vol. VII, 1969.

[13] Barber, Richard T., Unpublished results from progress report on NSF Grant GB–7691 to Woods Hole Oceanographic Institution, 1969.

[14] Hays, J. D., "Paleo magnetically Controlled Cenozoic Radiolarian-Stratigraphy in High and Low Latitudes," Abs. Geological Society of America.

[15] Glass, B. P., Heezen, B. C., 1967, "Tektites and Geomagnetic Reversals," Scientific American, vol. 317, p. 32–38.

[16] Clark, D. L., Paleoecology and Sedimentation in Part of the Arctic Basin. Arctic 22(3): 233–243, 1969.

sediments and fossil remains in relation to the sedimentation rate it has been determined that there is evidence of continental glaciation in the Arctic Basin 4 million years ago, this probably representing the beginning of Arctic ice conditions. Composition of sediments, plus display of certain temperature dependent morphological characteristics of fossils, indicate the Arctic has not been warmer than at present for at least 1.5 million years and that there is no evidence of the Arctic Ocean having been free of ice in a similar time period.

Water motion within the deep ocean (benthic) boundary layers has been studied through the use of self-contained instrument capsules dropped to the sea floor in the deep ocean to record current velocity, temperature, and pressures for extended periods of high sensitivity and then recalled acoustically to the surface.[17] Problems under study in depths exceeding 3 kilometers are the character of flow in the few meters just above the bottom, tides, and planetary waves.[18] Results imply a turbulent boundary layer several meters thick, the turbulence deriving from shear rather than geothermal flux. The bottom current is predominantly tidal.

An accurate measurement of the volume transport of the Gulf Stream extending over several years has been completed.[19] The measurements are of sufficiently high quality to provide data for testing modern physical theories. A series of direct transport and hydrographic measurements showed that the Gulf Stream extends to the bottom; as it does so, it becomes narrower. On both sides of the northward flowing water there is a deep counterflow.

Chemists have demonstrated that carbon monoxide is naturally transferred from the ocean to the air.[20] The exchange apparently accounts for as much as 10 percent of the carbon monoxide observed in the atmosphere. This finding is of major significance because scientists previously believed that nearly all atmospheric carbon monoxide was produced by man-made processes.

Extension of a previous hypothesis concerning the relationship of submarine volcanoes to a spreading sea floor has been extended to enable scientists to estimate where hazards to submarine navigation by submerged volcanoes or seamounts may be found.[21] In general, it appears to take about 10 million years for a volcano to grow to the ocean surface to form an island.

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[17] F. Snodgrass, "Deep Instrument Capsules," Science, vol. 162, pp. 78–87. 1968.

[18] Cauldwell, D., and F. Snodgrass, "Sensors and the Deep Sea," Physics Today, vol. 22, pp. 34–42, 1969.

[19] Richardson, Phillip, "Transport and velocity of the Gulf Stream at Cape Hatteras," M.S. Thesis, Univ. of Rhode Island, 1969.

[20] Swinnerton, J. W., Linnenbom, V. J. and R. A. Lamontagne, "The Distribution of CO between the Atmosphere and the Ocean," New York Academy of Sciences—Conference on Biological Effects of Carbon Monoxide, 12–14 January 1970, New York City.

[21] H. W. Menard, "Growth of Drifting Volcanoes," Journal Geophysical Research, vol. 4, No. 20, pp. 4827–4837, 1969.

Analysis of a series of cruises from the joint Navy-Smithsonian Institution's "Ocean Acre" program indicates that the vertical distributions for a number of critical species of fish and cephalopods demonstrate behavioral variations relevant to known characteristics of the deep scattering layers.[22] Of the numerically important species taken in the collections, some show clear evidence of diel migration patterns, while others have been identified as non-migrants.

A report has been completed of the geomorphology of the Middle Atlantic Continental Shelf region from Cape Cod to Virginia.[23] This report supplements 15 previously published large scale bathymetric maps of this region that were prepared by the Bureau of Commercial Fisheries. The report describes the shelf configuration and sediments and discusses its evolution and the processes involved in its formation. These charts will be extremely useful to fishermen in locating more precisely the kinds of bottom on which certain valuable resources concentrate.

The first rearing into the larval stage of the eggs of any species of tuna was accomplished at the BCF Tropical Atlantic Biological Laboratory.[24] Eggs of the little tuna, *Euthynnus,* caught in the Gulf Stream off Miami, Florida, were brought into the laboratory where they were hatched and the larvae reared to 20 days of age by feeding them on plankton. This allows scientists for the first time to identify the very early stages of the little tuna.

Finally, experiments in the possible hybridization of selected Atlantic and Pacific fish species indicate that this process can occur should certain migratory patterns be established.[25] These results indicate that further investigation is warranted, especially in view of the possibility of a sea-level canal between the Atlantic and Pacific Oceans.

Funding for the many and varied programs of U.S. marine research is shown in figure XI–2 and the distribution of funds to the major oceanographic laboratories is illustrated in figure XI–3.

The Distribution of Research

In 1968, the Marine Sciences Council designated the Science Information Exchange of the Smithsonian Institution as the national information center for unclassified, current marine science information. Specifically, the Exchange undertook the responsibilities for receiving, compiling, cataloging, and disseminating information concerning unclassified, ongoing research and development activities in the marine sciences.

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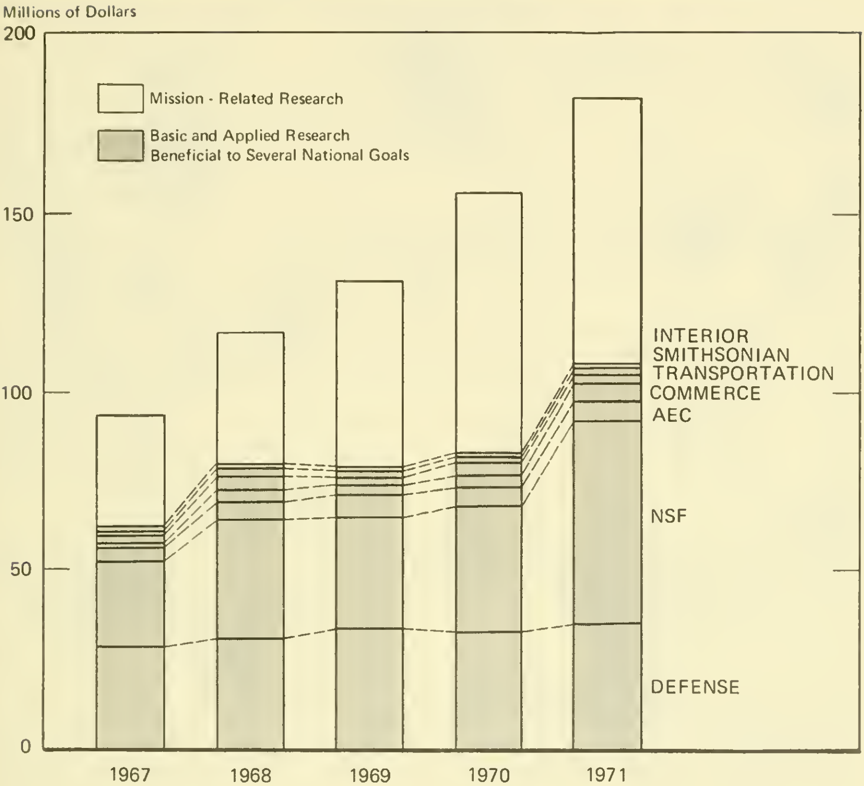
[22] U.S. Navy Underwater Sound Laboratory, New London, Conn. (Contract N00140–69–C–0166).

[23] Franklin Stearns, "Bathymetric maps and geomorphology of the Middle Atlantic Continental Shelf," U.S. Fish and Wildlife Service, Fishery Bulletin, vol. 68, No. 1, pp. 37–66, 1969.

[24] Houde, Edward P., and William J. Richards, "Rearing Larval Tunas in the Laboratory" Commercial Fisheries Review, vol. 31, No. 12, pp. 32–34, 1969.

[25] Rubinoff, R. W., and Ira Rubinoff, "Interoceanic Colonization of a Marine Goby through the Panama Canal," Nature, vol. 217, No. 5127, pp. 476–478, February 1968.

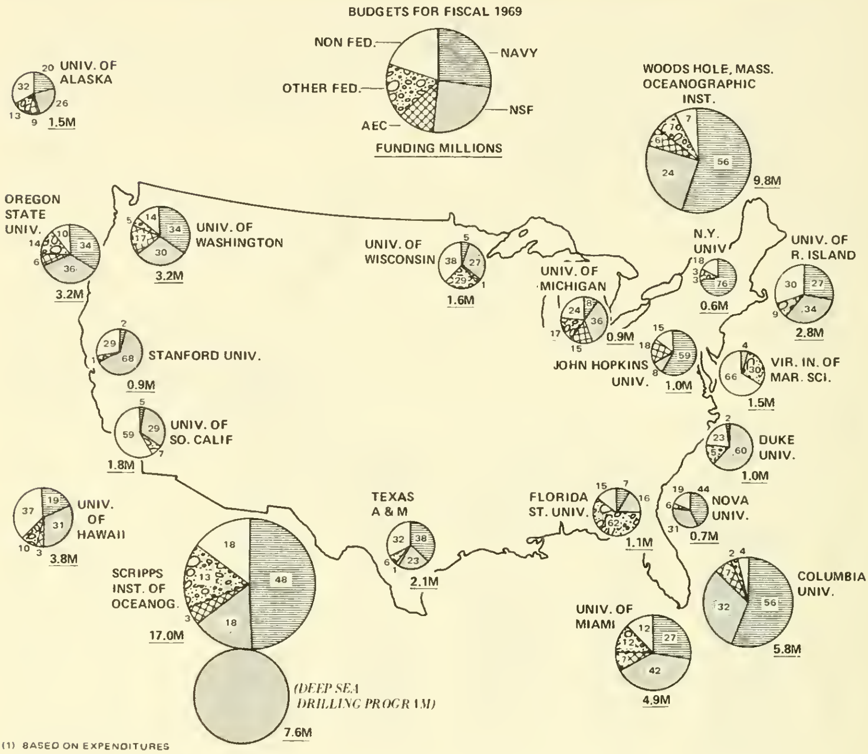
Figure XI-2—Funding for Oceanographic Research



As an initial project, the Exchange undertook the development of an inventory of Federal and non-Federal organizations with ocean-related research and development projects, published as "Marine Research—Fiscal Year 1968." This inventory contains descriptive summaries of 2,589 unclassified projects underway during the fiscal year 1968; the document represents a baseline from which national inventory of on-going research can be maintained.

In addition to serving as a project reference tool, the catalog reveals certain information about the geographic distribution of categories of research and development, amount of funds involved, and sponsors for these projects. Thus, States and regions with active academic institutions in proximity to coastal or lake areas, or with industrial interests in the sea, receive the bulk of project funding. Of the 41 States and territories receiving Federal support, 15 are the most active participants in the program by performing 66 percent of these projects while their Federal and State laboratories perform approximately 90 percent of all government in-house research and development projects. Table XI–2, developed from information contained in the catalog shows the distribution of research and development grants for fiscal year 1968 within the territorial United States.

Figure XI-3—Distribution of Funds to Major Oceanographic Laboratories



(1) BASED ON EXPENDITURES

SOURCE OREGON STATE UNIVERSITY

Manpower, Training, and Education

The training and education of personnel needed for the Nation's marine research and engineering development programs pose a continuing challenge. The range of skills and levels of competence needed is extraordinary. Most of the major scientific and engineering disciplines are involved, and educational levels from support technician to research scientist.

In the early stages of the development of the federally supported marine sciences program, one of the primary objectives was to build and restructure the sources of trained personnel. The rationale for this action, which is still valid today, was that the future course of oceanography and the "ocean-related" fields required more and better trained people at all levels, for program management as well as to carry out the ambitious programs envisioned for the 1960–70 decade.[26]

[26] The Marine Sciences Council publication, "University Curricula in the Marine Sciences and Related Fields," lists university courses in basic marine sciences, engineering, and associated fields throughout the United States.

Table XI-2—Marine Science Research and Development Projects [1]

[15 most active areas—fiscal year 1968]

Location	Federally supported [2] grants	Federal-State [3] in-house projects	Total projects
California	280	116	396
District of Columbia	22	323	345
Massachusetts	197	31	228
New York	154	16	170
Florida	119	37	156
Washington	81	69	150
Oregon	96	23	119
Alaska	26	64	90
Maryland	31	46	77
Rhode Island	37	38	75
Connecticut	39	31	70
Hawaii	26	44	70
Michigan	48	22	70
North Carolina	43	23	66
Texas	52	12	64
Total	1, 251	895	2, 146

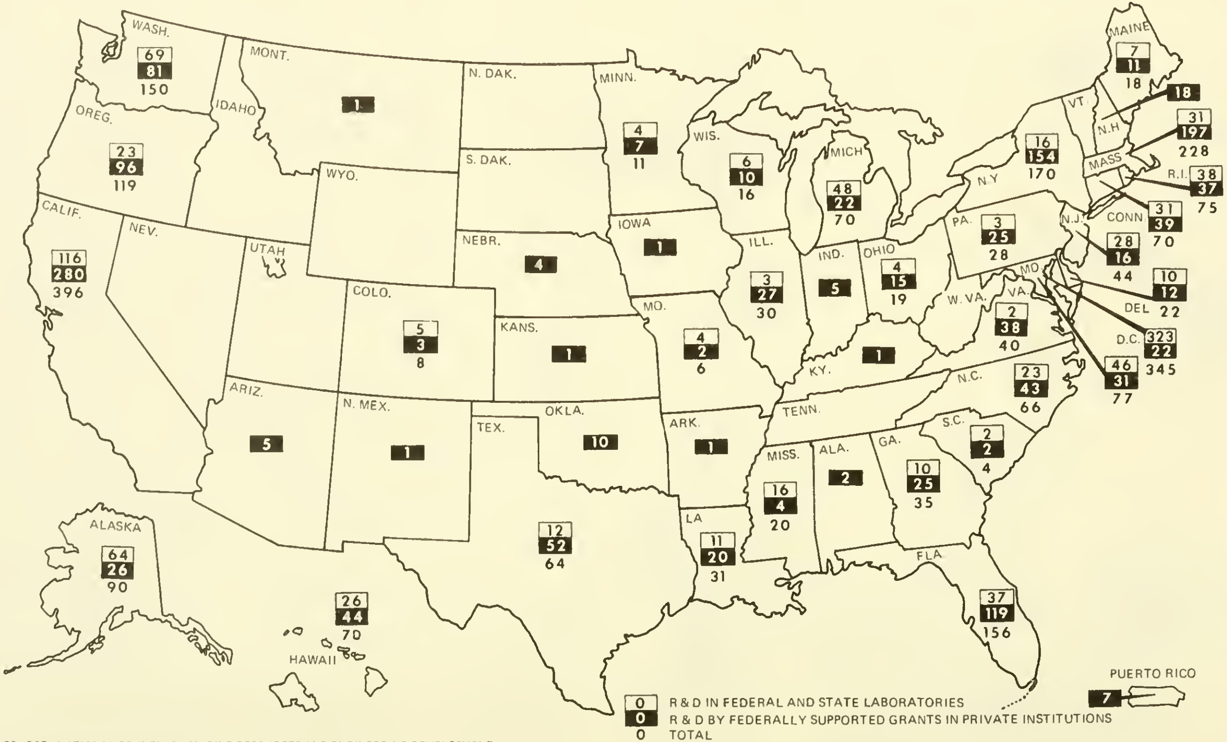
[1] Source: "Marine Research, Fiscal Year 1968," National Council on Marine Resources and Engineering Development, July 1969.
[2] Total Federally Supported Grants—1,564.
[3] Total Federal-State In-house Projects—1,025.

As a consequence of this conscious effort to enhance and augment the necessary pool of talent, the emphasis given to graduate and undergraduate training evidences a handsome return in ongoing academic programs and availability of manpower. This is shown in figure XI–4, indicating the results of Federal investment during the 1960's.

The introduction of newly trained personnel, plus the gain from scientists and technicians transferring into marine activities from other fields, has greatly eased the former manpower shortage in most marine science areas, permitting a high degree of selectivity in personnel utilization. This has been apparent in the growth of faculty for marine sciences courses taught at the university level which has been responsive to the growth in student interest as reflected in the rise in university enrollment (fig. XI–5). Although there has been significant manpower growth in the areas which are associated with traditional classical disciplines, there has also been a rapid expansion in applied areas. In addition to the over 3,000 students enrolled at all levels in oceanography and related marine sciences fields, the Enrollment Analysis also identifies 1,860 students in marine-related basic science, 1,104 in ocean engineering and marine-related basic engineering, 887 in naval architecture, 770 in marine food and fisheries science and 1,910 in marine operations and marine technology. Enrollment in associate degree and technician training courses accounts for 942 students who are not included in the growth curves in figure XI–5.

The market potential for marine sciences graduates at all levels, and for trained manpower in general, is becoming clearer. There are two reasons

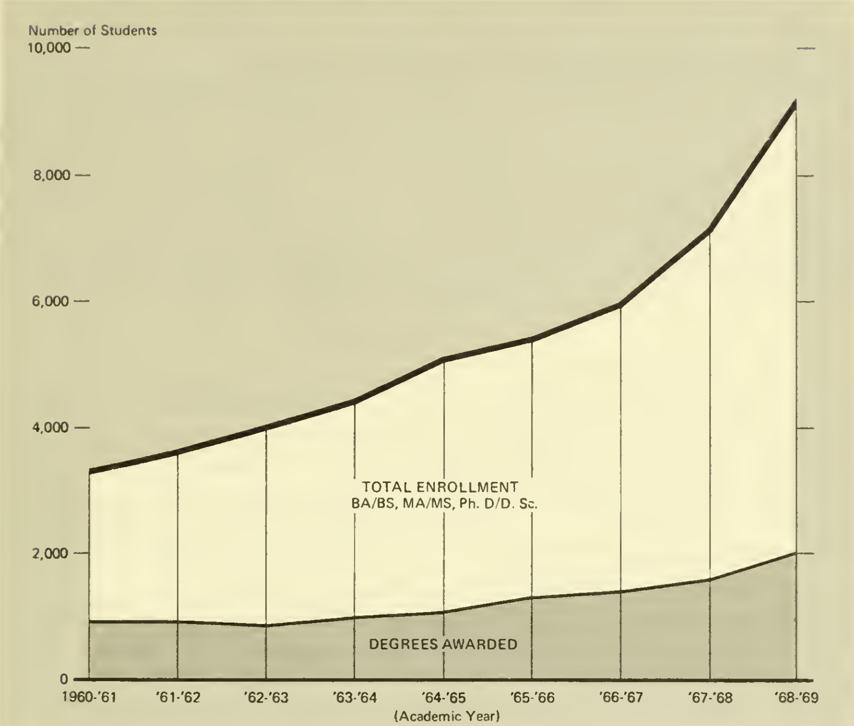
Figure XI-4—Distribution of Research and Development Grants,* Fiscal Year 1968



SOURCE NATIONAL COUNCIL ON MARINE RESOURCES AND ENGINEERING DEVELOPMENT

*WITHIN THE TERRITORIAL UNITED STATES

Figure XI-5—Degrees Awarded in Marine Sciences



*SOURCE. "AN ANALYSIS OF ENROLLMENTS AND DEGREES AWARDED IN THE MARINE SCIENCES AND RELATED FIELDS, ACADEMIC YEARS 1960-69," BY MARINE SCIENCES AFFAIRS STAFF, OFFICE OF THE OCEANOGRAPHER OF THE NAVY, DECEMBER 1969.

for this. As indicated, the academic manpower pool has grown to meet most current requirements due to the fruition of continuous Federal program support to numerous institutions. The second factor is the very close relationship of job opportunities to Federal funding in marine-related activities. Currently funds for research, development technology and engineering in support of marine sciences and engineering are providing for limited expansion above cost-of-living increases; this has had the effect of stabilizing available job opportunities in the face of rising personnel availability in most fields.

Federal support of education in the marine sciences is carried on primarily through the programs of the National Science Foundation, and the Department of Health, Education, and Welfare's Office of Education; NSF support ranges from secondary school student programs through the university undergraduate and graduate levels. The Office of Education provides assistance for trade and vocational education, college teacher fellowships, plus facilities and equipment grants in support of marine science programs. In addition, the Smithsonian Institution provides stipends for academic year and summer research training, and a significant part of the research grants and contracts of several other agencies with universities and research institutions is used to

support graduate students. The Office of Naval Research supports approximately 200 graduate students involved in research projects at oceanographic institutions. Agency support of these programs is as follows:

[In millions of dollars]

	FY 1969	FY 1970	FY 1971
Department of Health, Education, and Welfare	1. 3	1. 1	0. 8
Department of the Interior	([1])	([1])	([1])
Smithsonian Institution	([1])	([1])	([1])
National Science Foundation [2]	3. 5	5. 2	5. 5

[1] Less than $50,000.
[2] Sea Grant funds also support education and training (Table VII–1).

The Departments of Commerce, Defense, and Transportation provide graduate training and education for their civilian employees, to aid in career development. In addition, the Navy has a 2-year course in oceanography as a part of its Naval Postgraduate School at Monterey, Calif., and also sends selected officers to civilian universities for further specialized education. The Naval Oceanographic Office trains some 30 scientists annually, primarily foreign officers and civilians, in basic and applied oceanography and hydrography under funding support from the Military Assistance Program, the Agency for International Development, the United Nations Educational, Scientific and Cultural Organization and other sources. The Coast Guard operates a school of 21-weeks duration for its enlisted personnel to train oceanographic technicians. Agency funding of these programs is as follows:

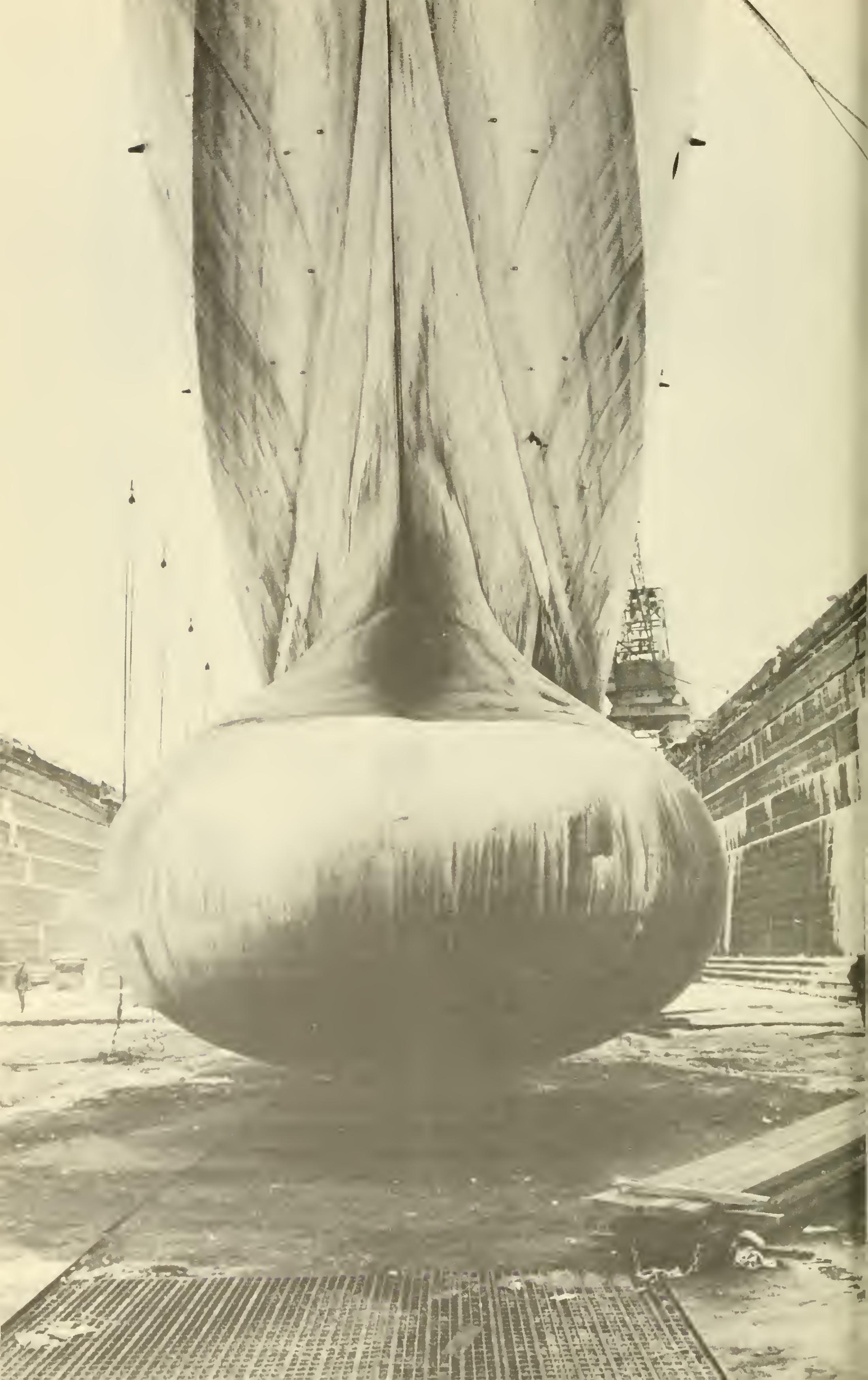
[In millions of dollars]

	FY 1969	FY 1970	FY 1971
Department of Commerce	0. 1	0. 1	0. 1
Department of Defense	1. 7	1. 8	1. 6
Department of Transportation	0. 1	0. 2	0. 2

Particularly encouraging from a long-range viewpoint is the increasing number of elementary and secondary schools which now include courses in their curricula to give students an overview of the oceans and their influence on mankind. Among the many school systems which have taken this forward step are Orange County, Calif., Cocoa Beach, Fla., and Kittery, Maine. In addition to the work carried out within the elementary curricula, several marine-oriented societies and private institutions have been actively supporting student activity in this area. The Marine Technology Society, the American Association for Oceanography, and the National Oceanographic Association have fostered a number of educational activities related to student awareness of the marine environment, and organizations such as Woods Hole Oceanographic Institution and the International Oceanographic Foundation have actively distributed information and advice to sec-

ondary and elementary school systems. Finally, each university under Sea Grant institutional support, as part of its advisory service mission, furnishes information to agencies, schools, industry, and the general public.

It is becoming apparent, in view of present fiscal conditions which do not permit the development of national marine sciences programs at the rate projected 3 or 4 years ago, that the average student graduating with a B.S. degree may find it necessary to proceed directly into a marine-oriented graduate program in order to compete successfully for professional positions. Current trends in ocean use will be reflected in projected training programs which are oriented toward developing more broadly-based environmentally-oriented marine scientists. This is a natural response to the projected national requirements as the Nation turns toward the utilization of the coastal zone and environmental problems.



Chapter XII

STRENGTHENING MILITARY PROGRAMS FOR NATIONAL SECURITY

Seapower in its broadest sense is indispensible to the achievement of the Nation's broad security, foreign policy, and economic and social goals. Freedom of the seas must be maintained to protect the United States from attack, to sustain our allies, to project our military power by sea when necessary, and to protect ocean commerce. The mobility and concealment provided by sea-based strategic nuclear forces makes them more survivable than fixed systems. Sea-basing tactical forces, such as attack carrier, antisubmarine warfare, and amphibious striking groups, offers a valuable alternative to the use of overseas bases.

The marine science programs of the Department of Defense, and particularly those of the Department of the Navy, are designed to provide the ocean science, engineering, development and operational techniques required for the conduct of assigned national security missions throughout the marine environment. Military marine science programs are thus directed toward enhancing U.S. capabilities for strategic deterrence, antisubmarine operations, support of amphibious operations, mine warfare, surveillance of the oceans, operations to protect essential shipping, and limited ground action.

Antisubmarine warfare, however, more than any other form of naval operations, is critically dependent upon oceanographic conditions. The Navy's work in this field typifies the application of oceanography to practical problems—the quest for scientific insight through research; improvement of equipment, data facilities, and techniques through development efforts; operational utilization, coupled with progressive system improvements; and finally, relation of benefits to nonmilitary programs.

The first antisubmarine warfare (ASW) application of underwater acoustics occurred in 1914 with the use of listening hydrophones to detect enemy submarines, and about the same time, echo ranging was used in attempts to detect icebergs. After a half-century, sonic ranging (active sonar) and listening (passive sonar) are still the backbone of antisubmarine warfare. The increasing sophistication of detection and weapon systems amplified their dependence on environmental information, particularly water temperature, to a level which could no longer be disregarded. This dependence led first to the development of the bathythermograph, which rapidly samples the thermal structure, and then to the application of statistical, atlas-type environmental information, to the prediction of sonar detection conditions.

The sonar dome on the bow of U.S.S. Belknap (DLG–26) *encloses the AN/SQS–26 transducers. Effective operation of long-range sonars depends upon a knowledge of oceanographic conditions.*

As more understanding was gained of the complexity and variability of the ocean it became apparent that these approaches were not fully adequate for operational purposes. The controlling environmental conditions have to be described on a broad, synoptic basis, and even more important, predicted for the future.

To develop an integrated system to observe, analyze, predict, and display oceanographic conditions which apply to ASW operations, resources for basic research at universities and applied research and development at Navy facilities were marshaled in 1959. Techniques were developed for forecasting many of the ocean's variables, and for applying these forecasts to specific operational ASW problems.

Antisubmarine Warfare Environmental Prediction

The major effort dedicated to ocean environmental prediction in support of fleet sonars is the Antisubmarine Warfare Environmental Prediction Services (ASWEPS) program. Initially developed by the Naval Oceanographic Office, ASWEPS was implemented as an operational oceanographic prediction system in 1966 by the Naval Weather Service Command and has since been continuously improved and expanded to provide fleetwide oceanographic services. Through this system, data gathered by the fleet and other sources are analyzed at oceanographic centers ashore. Charts of various oceanographic parameters are then sent in real time to ASW groups at sea where they are converted into sonar effectiveness information.

More recently, computers at shore-based facilities have been used to integrate oceanographic and weather data with sonar equipment factors. Sonar range predictions are then calculated and transmitted directly to fleet units. This has eliminated the need for transmission of some of the basic charts, and reduced the need for trained environmentalists aboard ship to interpret them.

The predictive system operated by the Naval Weather Service comprises a network of 33 activities that produce environmental predictions for the northern hemisphere oceans. The Fleet Numerical Weather Center at Monterery, Calif., is the hub of the Naval Environmental Data Network which links the computer facilities used in the collection, processing and dissemination of oceanographic and meteorological data and predictions. Large-scale automation is currently improving and expediting the system's output.

Forecasts provided include: sea and swell; subsurface current speed and direction; sea-surface temperature patterns; mixed layer depth; vertical profiles of temperature and sound velocity, sea ice conditions, optimum tracks for ship routing, and special factors relating to underwater surveillance programs. Various combinations of these factors are furnished as required by antisubmarine warfare and other fleet operations.

Although environmental and sonar range prediction are being used effectively now, continuing improvement is required. The most severe limita-

tion on the predictive system at present is the inadequacy of the environmental data input. As improved instrumentation is installed on ships, aircraft, and buoys, the quality and quantity of synoptic oceanographic observations will be greatly enhanced and the data base improved. New and revised forecasting models will be further exploited through the more extensive use of computers, and their performance checked both by fleet use and research experiments.

Although this prediction program is designed and used primarily for ASW purposes, several side benefits are being derived from the program. The Bureau of Commercial Fisheries, for example, is making use of the Navy's sea surface temperature predictions to guide fishermen into those areas where thermal conditions are most favorable. An agreement between the Department of the Navy and the Department of the Interior provides for joint cooperative efforts to study aspects of the ocean that are of mutual concern. One such cooperative effort is a study of "false targets" related to biological activity. From this study, the Navy will derive means to predict false targets, while the Bureau of Commercial Fisheries will gain information on potential fish resources. In another side benefit, ESSA's Weather Bureau has adapted numerical sea and swell prediction methods developed under this program to produce a standard product available to the general public.

To improve the capability in gathering and processing data, the program has also sponsored the development of new equipment such as shipboard and airborne expendable bathythermographs, the airborne radiation thermometer, airborne and shipboard wave meters, an automated shipboard forecasting system, and the 40-foot-diameter "monster buoy" as well as smaller buoy platforms.

As predictive techniques, instruments, and systems reach advanced development and successful evaluation, they are made available for fleet use. Through the process of testing and evaluation by the users, improvements are effected to assure that forecasts are reliable and presented as useful tactical indices for the on-scene commander.

The Scope of the Navy's Program

The Navy's oceanographic effort includes virtually every area of marine endeavor, and it has pioneered in many sectors of ocean science, engineering and operations. To further enhance the management of these efforts by providing strengthened organizational relationships, three major administrative actions were accomplished in the past year. In one, the Commander, Naval Weather Service Command, who is responsible for operational forecasting of the ocean environment for Navy needs, was designated as the Assistant Oceanographer for Environmental Prediction Services. He coordinates the collection and processing of synoptic data for short-term forecasting of ocean variables such as thermal structure, sea, swell, surf, and sea ice, and provides to the fleet the special analyses and forecasts necessary to support specific operations such as tactical ASW, amphibious landings, sea lift transits, and search and rescue.

The second action was the establishment of a Deep Submergence Systems Project Coordinator within the Office of the Chief of Naval Operations, charged with responsibility for the operational aspects of undersea search, rescue, salvage, and diving. In the third action, the Supervisor of Salvage was designated by the Naval Ship Systems Command as the Director of Diving, Salvage, and Ocean Engineering Projects to serve as the focal point for such efforts within that organization.

The importance of oceanography to the Navy in its long-term plans was emphasized in July 1969 when the first selection of officers into the new special duty category of Geophysics (Oceanography/Hydrography) was authorized. In December the first 41 officers from the fleet were selected, and planned total strength of the specialist group is 150.

Department of Defense funds proposed, which are categorized in this report as programs specifically for national security, amount to $116 million, about 22 percent of the total marine science budget. Overall, this represents a net decrease when compared with fiscal year 1970. Selective growth is reflected by increases in ARPA support of DOD requirements for an Arctic surface effects vehicle, by Navy emphasis of applied research in support of ASW, and in the construction of two small oceanographic utility vessels to replace aging and obsolete ships at universities which carry out Navy research projects. Offsetting decreases occur in such areas as Navy's operational surveys and deep submergence developments. Major allocations of these funds in fiscal year 1971 are:

	Million
Research, development, technology and engineering	$104
Operations	18
Investment	27

These data do not include information on the Navy's surface effects ship program, which amounted to $3.3 million in 1969, is estimated at $7.9 million in 1970, and is included in the President's budget request for 1971 at $20 million. The Navy oceanographic program amounts to $210.2 million in the fiscal year 1971 budget request. Efforts within this program are related to national security. While the Navy engages in oceanographic activities because of operational requirements, programs for military security also contribute substantially to the entire spectrum of national oceanic involvement. Various aspects of the Navy's overall program are discussed in other chapters of this report.

The knowledge gained from military programs is, to the maximum extent consonant with security considerations, made available in unclassified form for general use by Government, industry, and academic scientists and engineers. The Navy's program in mapping, charting and geodesy produces charts and publications which not only meet military needs for navigational materials, but also fulfill the Navy's statutory obligations to provide such services for mariners generally. All bathymetric data which would not compromise classified ship operations or installations are routinely made available for public use. Other fundamental oceanographic data, with very few exceptions, are also channeled to potential users, primarily through the National Oceanographic Data Center.

The Navy's comprehensive program in materials development, the most comprehensive in the Nation, provides knowledge for private shipbuilders and Federal maritime agencies such as ESSA, the Coast Guard, and the Maritime Administration. Navy developments in navigation, which have ranged from submerged acoustic position-keeping devices to global systems for precision ship location by satellite and VLF radio, have been released for scientific and commercial use. Environmental knowledge of the Arctic, collected by the Navy and the Corps of Engineers, has been made available to commercial developers of Arctic shipping. The programs of the Advanced Research Projects Agency, directed toward detection of underwater nuclear explosions, provide knowledge of the earth's crust and its energy transmission characteristics which is relevant to earthquake studies and volcanology.

From the standpoint of science and technology, however, it is difficult to separate those portions which also support nondefense goals in addition to their military mission. Therefore, military marine science efforts which make substantial contributions to other national needs are described in other chapters of this report to give a coherent picture of all Federal efforts in the relevant field of marine science activity.

The Navy's Hydroskimmer (SKMR–1) is being used as a research and operational test vehicle. Built by Bell Aerospace the 35-ton craft is the largest air-cushion vehicle constructed in the United States.

The Navy's Deep Submergence Rescue Vehicle (DSRV) is air-transportable, to permit its quick deployment to the vicinity of any fleet submarine casualty. Following subsequent transport aboard a "mother" submarine or surface ship, it could be used to locate and mate with a disabled submarine to effect personnel rescue and assist in salvage operations.

At the same time, a number of programs in civilian agencies contribute to improved Navy capabilities. The Environmental Science Services Administration's nautical charts, and surveys conducted both by ESSA and the Coast Guard, assist in meeting defense needs.

The Navy and Geological Survey have conducted a cooperative field survey in the Gulf of Mexico, in which the Geological Survey provided competence in geological and geochemical investigations which complemented Navy's expertise in physics and acoustics. As a result, at the same time that data needed for submarine and antisubmarine operations were provided, major contributions were also made to the Nation's knowledge of the geology and mineral potential of the Gulf.

Navy and ESSA have recently launched a concentrated cooperative geophysical survey of the mid-Atlantic, and of the Pacific coastal area off central and southern California. Navy was also a major contributor to the Barbados Oceanographic and Meteorological Experiment (BOMEX) coordinated by ESSA. Such cooperative marine science interchanges are encouraged to enhance the national ocean program and meet defense-oriented requirements.

Ocean Surveys for Defense Systems

The Navy's ocean surveys are designed to provide oceanographic, hydrographic, and acoustical information about ocean areas in which our naval forces operate. They provide environmental data to support current fleet operations as well as the optimum design of future systems. Oceanwide surveys, including both those listed below and those mapping and charting programs listed in chapter IV, provided vast quantities of precise environmental data over millions of square miles of ocean during 1969.

Surveys in support of ASW systems were conducted in the Western Pacific and the Gulf of Mexico, the latter, in part, as the cooperative project with the U.S. Geological Survey referred to earlier. A portion of the survey of the South China Sea also aided the U.N. Economic Commission for Asia and the Far East (ECAFE) in its scientific and economic evaluation of the area. It included the assistance of scientists from several Asian nations. Results of the ASW surveys include 125,000 miles of shallow sub-bottom profiling and bathymetry, 76,000 miles of deep seismic profiling, 86,000 miles of magnetic field measurement, and 5,000 miles of gravity data. Acoustics information and data on the water mass and bottom sediments were also obtained.

Surveys to collect data applicable to mine warfare and mine countermeasures were conducted in southeast Asia, the Mediterranean, and off the Pacific coast of the United States. Some of these surveys utilized host-country ships and scientists, with U.S. scientific advisers aboard. Typically, these surveys included extended-period bottom current measurements, bottom cores, sub-bottom profiling, and bottom conductivity measurements.

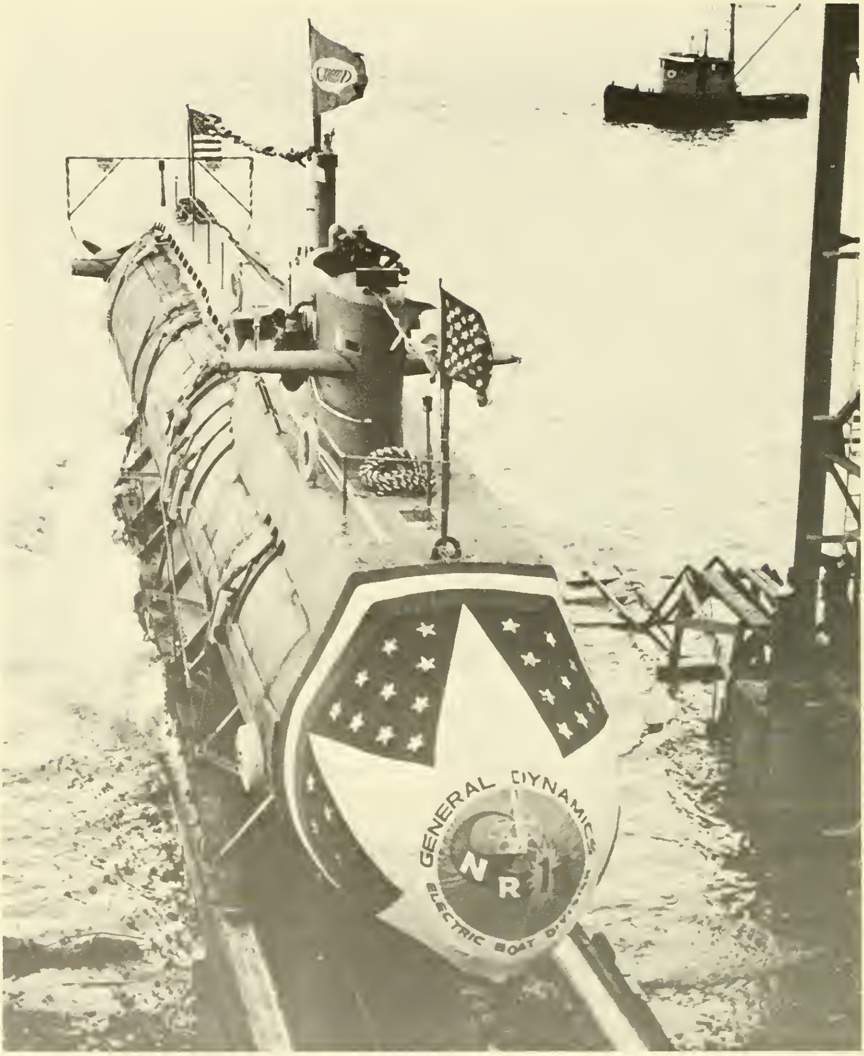
Science in Support of Defense Systems

Marine science and technology activities in support of specific weapons systems are directed primarily toward developments in underwater sound to support sonar and surveillance. The primary objective is to enhance the capability of the United States to counter hostile submarine forces, but the knowledge gained also aids in the concealment of U.S. submarines, thus contributing to the effectiveness of the fleet ballistic missile system. A wide variety of projects at Navy, private and industrial laboratories are coordinated within this program of investigation. Major recent accomplishments included the following:

1. Experimental data to provide essential inputs to predictive models of advanced sonar performance were taken in the Pacific and Indian Oceans, in part as a cooperative effort with the Royal Australian Navy.

2. For the first time, the Navy's two stable ocean platforms, FLIP and SPAR, were operated together in an experiment north of Puerto Rico. They conducted acoustic propagation studies, including surface and bottom interactions, absorption and scattering, measurements vital to sonar performance.

3. *Turtle* and *Sea Cliff,* two new 6,500-foot-depth deep submergence vehicles similar to *Alvin,* were launched. Upon completion, *Turtle* will operate in part at the Atlantic Undersea Test and Evaluation Center (AUTEC)



The U.S. Navy's nuclear-powered undersea research and ocean engineering vehicle NR–1 was launched in January 1969. The NR–1's long submerged endurance and large instrumentation capacity will bring a new dimension to the study of marine problems.

in the Bahamas. *Sea Cliff* will be used in Navy research programs by the Woods Hole Oceanographic Institution.

4. Instrumentation was installed to bring to eight the number of major ships involved in the Navy's ocean research program now equipped with on-board computer systems for real-time reduction of data. By providing results immediately, these systems allow the scientist to make a preliminary analysis of his experiment while on scene and to correct any unsatisfactory aspects. While these systems currently find their most intense application in under-

water acoustics, geophysics, and physical oceanography, it is anticipated that they will be increasingly employed in other areas of marine science.

Undersea Recovery and Man-in-the-Sea

This portion of the Navy's comprehensive program in ocean engineering is intended to improve the Navy's deep ocean operational capability in submarine rescue and escape, search and location, salvage and recovery, and diving operations. The need for such a capability was first emphasized by the loss of the submarine *Thresher* in 1963. This need was reemphasized in 1966 with the loss of an unarmed nuclear weapon off Palomares, Spain, and again in 1968 with the loss of the submarine *Scorpion*.

The systems under development in the deep submergence program respond to Navy mission requirements for—

(1) Submarine location, escape, and rescue;
(2) Object location and small object recovery;
(3) Man-in-the-sea;
(4) A nuclear-powered research and engineering submersible, (NR–1);
(5) Large object salvage; and
(6) Deep Submergence biomedicine.

The submarine location, escape and rescue program is developing a system which will give the Navy the capability to—

(1) Locate a distressed submarine;
(2) Provide personnel escape techniques and equipment for individual escapes from depths to 850 feet; and
(3) Provide an all-weather rescue system, operational to submarine collapse depths using deep submergence rescue vehicles (DSRV's).

Construction of the first DSRV is complete; the vehicle was launched in January 1970; and an extensive at-sea test program has commenced. Fabrication of DSRV II is nearing completion, and its testing schedule will follow that of DSRV I by about 6 months. DSRV I is scheduled to mate with a simulated submarine in distress, then mate with and be transported by the test and evaluation submarine *Salmon,* which will be configured as a DSRV "mother" submarine.

Two new catamaran hull submarine rescue ships, capable of transporting and maintaining DSRV's, have been launched. The *Pigeon* (ASR–21) is scheduled for delivery in late 1970; it will be followed by the *Ortolan* (ASR–22) in early 1971.

The U.S. Navy has been evaluating the submarine escape and immersion equipment being developed by the Royal Navy to determine its suitability for use on U.S. submarines.

The development objective of the object location and small object recovery system is to develop the capability to locate and recover small objects at depths as great as 20,000 feet. Development of necessary fabrication techniques and tests of structural and buoyancy materials are proceeding. The

present capability for location and recovery of small objects at these depths rests with the proven but limited bathyscaph *Trieste II*. This vehicle viewed and photographed the *Scorpion* hulk in greater than 10,000 feet of water during a record 120 hours submerged, which spanned nine dives in a 7-week operating period.

The Navy's man-in-the-sea project is directed toward developing new equipment to permit men to live and do useful work underwater. Both the Navy and private industry have cooperated in developing the equipment and techniques by which divers can work for longer periods in the sea, at greater depths, and with better tools and increased safety. Some aspects of these activities are discussed more fully in chapter VIII.

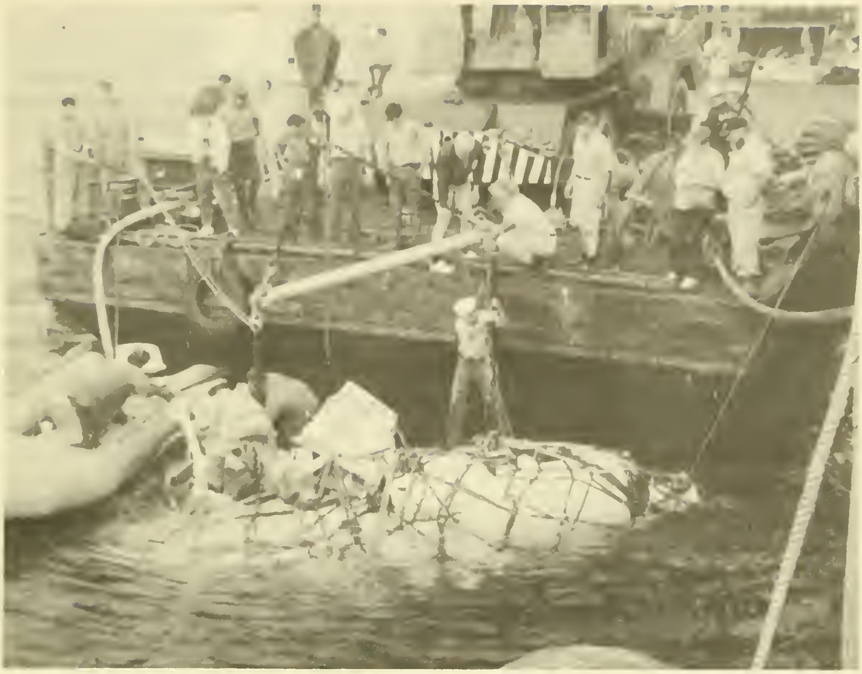
The Navy's Sealab III experiment has been the recent focal point of this project. As a result of the many lessons learned, Sealab III has been restructured as a four-phase experiment. The first three phases involve the evaluation of aquanaut equipment and techniques and the validation of biomedical data at progressively deeper depths until a 600-foot capability has been verified. The fourth phase will include the habitat living experiment; however, this phase has been delayed until fiscal year 1972 due to funding limitations.

In support of man-in-the-sea goals, a program with Duke University tested thermal protection systems for divers, under saturated diving conditions, to simulated depths of 600 feet. Psychological tests were conducted at water temperatures of 90° and 45° F. and indicated that with adequate thermal protection and underwater breathing systems diver performance was satisfactory.

The Navy's nuclear-powered research and engineering submersible, NR–1, was delivered in October 1969, upon the completion of successful sea trials. In addition to demonstrating the feasibility of nuclear propulsion at deep depths, NR–1 provides a valuable capability to conduct extended search, recovery, survey, and surveillance missions to her test depth. A shakedown cruise is scheduled in 1970, to demonstrate the endurance and performance of both the submersible and her crew. This will include surveys of the ocean bottom, canyon navigation, visual inspection of a sunken hulk, and other mission-oriented exercises preparatory to her operational utilization.

The large object salvage system (LOSS) development responds to a Navy mission requirement to be able to recover large objects, including intact submarine hulls, from depths down to 850 feet. Culminating a 2-year effort, the related MK–I portable deep dive system was delivered and is now being tested at progressively deeper depths down to 850 feet. Air-transportable, this system has been designed primarily to support worldwide salvage requirements from ships of opportunity. Feasibility studies, lift hardware development, and coordination with other deep ocean projects is in progress to devise an integrated salvage systems package.

In August 1969, the Navy successfully accomplished the largest deep recovery on record. The deep submersible *Alvin* was recovered from a depth of over 5,000 feet in the North Atlantic, where she had been lost almost a year earlier. This recovery feat was primarily accomplished through the



The Navy/Woods Hole research submersible Alvin *is seen being recovered after almost a year on the bottom off the New England coast. A recovery team of surface ships worked with the submersible* Aluminant *to retrieve the research craft from over 5,000 feet of water.*

cooperation of the Navy research ship *Mizar* and the commercial submersible *Aluminaut.* The combination of great depth, long lift, and great weight posed unprecedented problems. After several exploratory dives, *Aluminaut* attached a toggle bar to *Alvin's* hatch which led to a 4½-inch nylon lift line led through the *Mizar's* center well. Once surfaced, *Alvin* was suspended under a salvage pontoon and towed homeward, in remarkably good condition after her long submergence.

The Navy has an integrated deep submergence biomedical development program which has as one of its objectives the safe and efficient underwater operations by divers to depths of 1,000 feet for periods of up to 30 days. The Bureau of Medicine and Surgery has produced a development plan for attainment of this objective by 1977. Total biomedical efforts now underway support all facets of Navy's deep submergence program, including ambient pressure diving and vehicle and habitat occupancy.

Ship Construction

The years 1970–71 mark the completion of a major transitional period for the Navy's operational oceanographic fleet—the completion of the programed phasing out of obsolete converted military ships, manned by naval personnel, and their replacement by new ships specifically designed and in-

strumented for oceanographic work, and manned by Military Sea Transportation Service civilian crews. In fiscal year 1971, 11 Navy ships will be dedicated to the collection of operational oceanographic data, which total includes the hydrographic mapping and charting effort described in chapter IX.

During fiscal year 1970, two hydrographic survey ships, the USNS *Kellar* and USNS *Lee,* became operational, and the USNS *Chauvenet* is soon to be delivered. In fiscal year 1971, the USNS *Harkness* and USNS *Wyman,* and one oceanographic survey ship, the USNS *Wilkes,* will be delivered. Fiscal year 1970, however, will see one oceanographic and four hydrographic survey ships permanently retired from service. Though the total number of ships to be applied to operational surveys is less in fiscal year 1971 than in fiscal year 1968, the increase in efficiency achieved by the new platforms should actually enhance the Navy's survey capability.

In addition to the survey fleet acquisitions, in fiscal year 1970 two new oceanographic research ships supporting on-going Navy programs, the USNS *DeSteiguer* and USNS *Bartlett,* became operational. They replaced two older research ships which have been temporarily placed in reduced readiness status. A new design oceanographic research ship, the USNS *Melville* was delivered to Scripps Institution of Oceanography, and a sister ship will be delivered to Woods Hole Oceanographic Institution by the end of fiscal year 1970. The new catamaran-hulled research ship which will support Navy's on-going underwater acoustic program is scheduled for delivery in fiscal year 1971.

The fiscal year 1971 budget includes funds for two ships of a new, small class (under 300 gross tons) to provide an economical, versatile platform for the shorter cruises which make up a large proportion of oceanographic ship research schedules. These vessels will replace ships of World War II and older vintage now used by universities in carrying out Navy's programs.

The Advanced Research Projects Agency

To improve the ability to detect, locate, and identify underground and underwater nuclear explosions, the Advanced Research Projects Agency (ARPA) of the Department of Defense has for several years conducted Project VELA. The portion of this research and development program involving detection, location and identification of explosions in the ocean was successful and has been discontinued.

Related study of the properties of the ocean that are relevant to onsite inspection techniques for underwater nuclear explosions will be completed by the end of fiscal year 1970. As part of the study a computer program has been developed to simulate and predict the oceanographic evolution of deep subsurface pools of contaminated water which might follow an underwater nuclear explosion. A 250-ton detonation off the Aleutians on September 6, 1970, concluded development effort on a prototype vessel for large cargoes, and provided additional guidelines for the application of calibration explosions to improve our ability to locate events taking place in island arc structures.

Ten ocean-bottom seismographs were deployed off the Aleutians to monitor local seismic activity before and after the MILROW nuclear experiment of October 1969, and to determine the extent of possible earthquake activity induced by large-yield underground nuclear explosions. Eight of the units were successfully recovered after the event, and data are being analyzed.

In concert with the Navy program, ARPA is also engaged in other advanced marine science military applications. Areas of particular interest which will be investigated relate to (1) new technology for floating bases, and (2) the attainment of Arctic mobility over the ice pack and adjacent shores. Projects include—

(1) The development of an Arctic surface effect vehicle (SEV). The Arctic has been picked for attention because of its significance to national security. The polar region will be studied as an operating environment for the SEV and key Arctic technologies will be developed. Conceptual design studies for mission-oriented vehicles will then be initiated; and

(2) Design and technology studies for floating bases will continue; some 1/100 scale model testing will be carried out with more promising concepts to be tested further at larger scales.

The United States earnestly hopes for and works toward resolution of the international conflicts which may make defense measures necessary. Until such efforts succeed there is no prudent alternative to the maintenance of adequate protective forces and systems, and ocean science and engineering are essential to enhance the effectiveness of these forces. The military oceanography programs are tailored to support particular systems, in geographical areas and on specific time schedules. The challenge to scientists and engineers is to satisfy these overriding primary needs, to insure that the knowledge is advanced and, to the maximum extent feasible, to use the data, technology and research results available from other economic and scientific fields.

Chapter XIII

EXPANDING INTERNATIONAL COOPERATION AND UNDERSTANDING

The world ocean washes the shores of more than 100 nations. Yet the deep sea knows no political boundaries; it is inherently international. New oceanic technologies are also global, and as industry and nations use these technologies for exploration and exploitation and undertake activities more intensively, farther and farther from shore, international interest in the ocean increases.[1] As interests and operations increase and converge, competition for resources grows. Thus international cooperation in ocean activities becomes important to foster world order and development and to prevent and mitigate conflicts and rivalries.

International cooperation is also needed to obtain more and better information about the oceans. Because of the size, complexity, and variability of the marine environment, international cooperation in scientific investigations is needed if many aspects of the oceans are to be studied in a reasonably short and useful period of time. The United States—and all nations—can derive maximum benefit from the marine environment if they share the responsibilities and the results of their collective capability in ocean research.

A multinational approach to the peaceful uses of the seas is desirable and necessary. The Marine Sciences Act calls for cooperation with other nations, groups of nations and international organizations in marine science activities.[2] The United States is seeking to further international understanding in its expanding activities in the oceans, to encourage other nations to

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[1] The increasing worldwide activities in marine science affairs are described in the following five Marine Sciences Council publications: "Marine Science Activities of the Nations of Africa," "Marine Science Activities of the Nations of East Asia," "Marine Science Activities of Canada and the Nations of Europe," "Marine Science Activities of the Nations of Latin America," "Marine Science Activities of the Nations of the Near East and South Asia." These and other Council publications are listed in app. C–3.

[2] As international policy objectives, sec. 2 of the act states: "The preservation of the role of the United States as a leader in marine science and resource development." Also, "* * * The cooperation by the United States with other nations * * * in marine science activities when such cooperation is in the national interest." Section 6 of the act states: "The Council, under the foreign policy guidance of the President and as he may request, shall coordinate a program of international cooperation in work done pursuant to this Act, pursuant to agreements made by the President with the advice and consent of the Senate."

The U.S. and Soviet research vessels Albatross IV *(foreground) and* Albatros *steam in company during a cooperative fisheries research cruise off Southern New England in 1969.*

determine how the oceans can contribute to their development, and to promote cooperative endeavors by—

(1) Encouraging increased cooperation among ocean scientists of all nations and broadened dissemination of scientific results;

(2) Collaborating with other nations in developing and using new marine technologies within a framework of mutual benefit;

(3) Encouraging the developing nations to use the oceans and their resources to foster economic progress, recognizing the need for assistance from many nations and international organizations;

(4) Supporting the activities of the many organizations of the United Nations system and other international organizations engaged in oceanic activities;

(5) Fostering cooperation among nations in exploring the oceans, sharing the costs and the benefits;

(6) Developing an effective and just code of international law which will preserve the traditional freedoms of the seas, insure that nations have equitable opportunities to participate in and share the development of the wealth of the oceans, and anticipate and prevent potential conflicts arising out of expanding national interest in the marine environment; [3]

(7) Fostering international legal, financial, and political arrangements to promote investment in maritime development and facilitate a fruitful partnership between public and private interests in maritime matters;

(8) Taking steps to reduce pollution and other activities which could adversely affect the global ecological balance;

(9) Cooperating in development of proposals for arms limitations on the seabed and ocean floor;

(10) Encouraging all nations at a policy level to examine their interests in the ocean and strengthen their capabilities and to participate in multilateral endeavors; and

(11) Fostering cooperation among neighboring nations to meet common interests and problems.

This policy framework reflects the many distinctive contributions that ocean activities can make to U.S. foreign policy goals: enhancing the prospects for peace, strengthening the world economy and providing new opportunities for developing nations, promoting regional cohesion, and providing new sources of protein for the expanding world population. It is also consistent with the recommendations of the Commission on Marine Science,

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[3] The following Council contract reports discuss many of the international law considerations of importance to the marine environment: "Law for the Sea's Mineral Resources," "Comments on Fishery Policy and International Law," "International Legal Problems of Scientific Research in the Ocean," "The Role of Marine Sciences in Multiple Use of Lakes Erie and Superior." These and other reports prepared by contractors for the Council are listed in app. C–2.

Engineering and Resources that the United States propose a new international framework (principles, rules, procedures, and institutions) for exploring and exploiting seabed mineral resources and for pursuing scientific inquiry in the oceans.

Developing such a policy framework, particularly regarding jurisdiction over the deep seabed, involves a number of considerations of national interest—security, economic growth, incentive for private investment, balance of payments, scientific research, aid to developing nations and others. These diverse interests find their advocacy in different departments of the Federal Government. Conflicts in viewpoint are inevitable and understandable in view of legitimately differing missions and responsibilities. To assist in formulating consistent Government-wide policies of international interest the Committee on International Policy in the Marine Environment continued to examine the major international ocean policies. The Committee assists the Secretary of State in advising the President and the Marine Sciences Council.

Preventing a Seabed Arms Race

One of the Nation's principal international initiatives in the oceans during 1969 was that taken to assure that the seabed remains free from the nuclear arms race. This objective was pursued within the forum of the Eighteen Nation Disarmament Committee in Geneva, which grew to 26 nations and was renamed the Conference of the Committee on Disarmament during the year. In March, the U.S. delegation entered these discussions with instructions from the President to work toward a seabed arms control agreement. Discussions were subsequently held to consider United States and Soviet draft treaties. In October the United States and Soviet delegations agreed on a draft treaty proposal under which parties to the treaty would undertake not to implant or emplace on the seabed and the ocean floor and in the subsoil thereof beyond the maximum contiguous zone any objects with nuclear weapons or any other types of weapons of mass destruction as well as structures, launching installations or any other facilities specifically designed for storing, testing or using such weapons.

In the fall the United States-Soviet draft was considered by the Conference of the Committee on Disarmament, the U.N. Seabeds Committee, and the U.N. General Assembly. This draft was discussed in detail; suggested changes proposed by many nations were considered; and the General Assembly referred the Draft Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Seabed and the Ocean Floor and Subsoil thereof back to the Disarmament Conference for further work and completion if possible.[4]

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[4] The text of the U.N. resolution and the draft treaty are presented in app. D–2.

Developing a Legal and Political Framework for the Seabed

An oceanic issue of primary importance before the world's nations is that of the legal status of the seabed and deep ocean floor. In 1969, most discussions of the political and legal seabed framework took place in the U.N. Seabeds Committee,[5] established in the fall of 1968 by the U.N. General Assembly, and in the Political Committee of the General Assembly.

The Seabeds Committee met in March, August, and November of 1969. Its report served as the focal point for the General Assembly debates on seabeds. The legal subcommittee of the Seabeds Committee devoted primary attention to carrying out the mandate of the 23d General Assembly: To formulate legal principles which would promote international cooperation in the exploration and use of the seabed. It made progress toward this goal by synthesizing certain legal principles for the seabed and ocean floor beyond national jurisdiction. The United States, since first presenting its own set of draft principles on June 28, 1968, has strongly advocated the need for an international agreement on a set of principles. The Seabeds Committee will continue to work toward agreement on these principles at its next session in March 1970.

The U.S. principles state that no nation may claim or exercise sovereignty or sovereign rights over any part of the deep ocean floor, that internationally agreed arrangements should be adopted as soon as practical to govern exploitation of deep ocean floor resources and that an internationally agreed precise boundary should be established for the deep ocean floor. They also set out guidelines for the conduct of the activities of states and their nationals on the deep ocean floor.[6]

The economic and technical subcommittee of the U.N. Seabeds Committee focused its attention in 1969 on a report submitted by the U.N. Secretary General setting forth an analysis of possible types of international organizational machinery which might govern exploitation of the deep seabeds. At the August session, the United States put forward a position on international machinery, stating that such machinery, as a part of an international regime, could include an international registry of claims governed by agreed criteria and supplemented by appropriate procedures. Under such machinery, governments would be responsible for adherence by their nationals to internationally established criteria, and the system would require adequate procedures for verifying compliance. The U.S. representative pointed out that no more and no less machinery should be created than would be required.

In these seabed discussions a number of developing nations suggested the need to create an international agency which would regulate and control seabed exploitation. A few countries suggested that the international authority should itself engage in exploitation.

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[5] The establishment of the Seabeds Committee and the nature of its first year of work are reported in ch. III of the Council's third annual report, "Marine Science Affairs—A Year of Broadened Participation," January 1969.

[6] The Draft Resolution of Principles supported by the United States in the U.N. Ad Hoc Seabed Committee are published in app. C–2 of "Marine Science Affairs—A Year of Broadened Participation," the Council's third annual report, January 1969.

In November the Seabeds Committee discussed the Draft Treaty on Prohibition of the Emplacement of Nuclear Weapons and other weapons of Mass Destruction on the Ocean Floor and the Subsoil thereof, which was then before the General Assembly for consideration. But the Seabeds Committee did not seek to arrive at any conclusion or recommendations.

In the fall of 1969 the 24th U.N. General Assembly reviewed the Seabeds Committee's report and debated it at length in the Political Committee. In December, the Assembly adopted four resolutions 2574 A–D (XXIV), on seabeds—

(1) Requesting the Secretary General to ascertain the views of member states on the desirability of convening at an early date a Law of the Sea Conference dealing with the full range of law-of-the-sea issues, including the seabed;

(2) Referring substantive seabed issues entrusted to it back to the Seabeds Committee and asking the Committee to prepare a comprehensive, balanced set of principles in time for the 25th General Assembly;

(3) Requesting the Secretary General to prepare a further study on various types of international machinery, particularly a study on machinery with extensive powers; and

(4) Declaring that states and persons, physical or juridical, are bound to refrain from all activities of exploitation of the resources of the deep seabeds, pending the establishment of an international regime.[7]

The United States opposed the first of these resolutions because it believes that treating all of the law-of-the-sea issues, including seabeds, at a single Law of the Sea Conference would only increase the difficulty of making progress on any of these issues. The United States cosponsored the second resolution, because it considers that the Seabeds Committee is the proper international forum for performing the in-depth work necessary to move forward on important seabeds issues. On the third resolution, the United States took the view that a further study by the Secretary General would be a useful supplement to his earlier report. The U.S. representative stressed, however, that the report should be balanced and not weighted in favor of one type of machinery as compared with other possibilities. The United States strenuously opposed the fourth resolution, which amounted to a call for the prohibition of all further exploitation of the deep seabeds, pointing out that such a freeze would be unwise and could spur initiatives for national extensions of jurisdictions over the seabeds. The United States observed that the resolution also ran contrary to the spirit of Resolution 2467 (XXIII), which had created the U.N. Seabeds Committee to promote international cooperation in exploration and exploitation of the seabeds.

In developing its position for discussing substantive issues in the U.N. Seabeds Committee and in the General Assembly, the Government consulted with Members of Congress and the public. In 1970, March and August sessions of the U.N. Seabeds Committee are scheduled.

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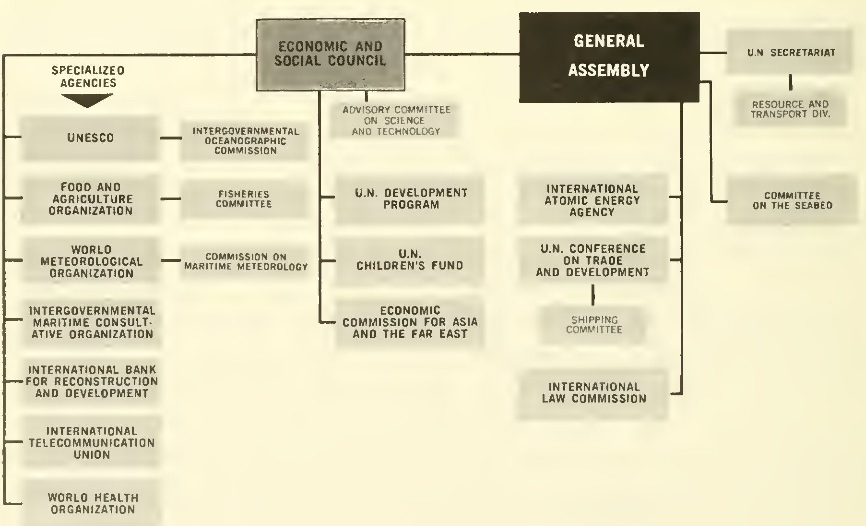
[7] The texts of the U.N. resolutions of 1969 are presented in app. D–1.

Broadening Marine Science Activities of the U.N. Agencies

The United Nations and specialized agencies of the U.N. system have continued to expand their activities in marine sciences on a worldwide basis, with the substantial support and the participation of the United States. No single international organization provides a complete overview of ocean activities. But over the past year, cooperation and coordination among the various U.N. organizations involved in ocean affairs have improved significantly. The U.N. General Assembly has maintained continuing interest in marine science activities and has encouraged close working relations among agencies in the U.N. family. The extent of U.S. participation in selected intergovernmental organizations marine programs is listed in table XIII–1. Figure XIII–1 identifies U.N. bodies with major responsibilities in the marine sciences.

The United Nations 24th General Assembly adopted three resolutions concerning marine science.[8] A resolution on marine pollution requested a review of the harmful, chemical, radioactive, and waste substances in the ocean; a report on national and international efforts to prevent and control marine pollution; and a survey of the views of member states on whether international treaties on marine pollution are desirable and feasible. A resolution on marine coordination suggested that the Economic and Social Council's (ECOSOC) committee for program and coordination might examine the need for a comprehensive review of U.N. activities relating to the oceans, including marine science activities. The General Assembly also adopted a resolution expressing appreciation for the Intergovernmental Oceanographic Commission's (IOC) Comprehensive Outline of the Scope of the Long-Term and Expanded Program of Oceanic Exploration and

Figure XIII–1—U.N. Bodies With Responsibilities in the Marine Sciences



[8] The texts of the U.N. resolutions are presented in app. D–1.

Table XIII-1—U.S. Contributions to Selected Intergovernmental Organizations for Marine Programs

[In thousands of dollars]

	Fiscal year 1969	Fiscal year 1970	Fiscal year 1971
Food and Agriculture Organization: [1]			
Regular budget	1, 026	1, 026	1, 058
U.N. development program	3, 360	3, 800	4, 260
FAO subtotal	4, 386	4, 826	5, 318
U.N. Educational, Scientific and Cultural Organization: [2]			
Regular budget	110	131	131
U.N. development program	77	114	114
UNESCO subtotal	187	245	245
International Maritime Consultative Organization:			
Regular budget	103	111	121
U.N. development program	79	79	79
IMCO subtotal	182	190	200
International Hydrographic Bureau: Regular budget	15	16	16
Total	4, 770	5, 277	5, 779

[1] Fisheries Department.
[2] Oceanographic activities, including Intergovernmental Oceanographic Commission.

Research. The resolution commended past cooperation among U.N. organizations in marine science and requested further cooperative efforts on the part of member states and United Nations and other organizations in implementing the program outlined by the IOC.

In 1969, ECOSOC considered several reports relating to marine science. It approved and decided to publish as a U.N. publication "Mineral Resources of the Sea," a completed and updated report on mineral resources on and beyond the Continental Shelf. It also reviewed a report on "Marine Science and Technology" which had been prepared in 1968 by the U.N. Secretary General. The ECOSOC also considered the IOC's report on the Long-Term and Expanded Program of Oceanic Exploration and Research.

During the debate on the latter report, the cooperation which has developed in the U.N. family relating to the Expanded Program was emphasized, and it was announced that the U.N. was joining with UNESCO, the World Meteorological Organization (WMO), the Intergovernmental Maritime Consultative Organization (IMCO) and the Food and Agriculture Organization (FAO) in creating an Intersecretariat Committee on Scientific Programs Relating to Oceanography. ECOSOC also endorsed the role of

IOC in connection with the scientific aspects of oceanography and decided to request the U.N. Secretary-General, in cooperation with the specialized agencies, to report regularly to the Council on progress in marine science.

During 1969 the IOC increased its activities in cooperation with other U.N. agencies to fulfill its role as a focal point for planning and coordinating the Expanded Program. A Joint Working Party nominated by the WMO, the Scientific Committee for Oceanic Research (SCOR) of the International Council of Scientific Unions (ICSU) and the Advisory Committee on Marine Resources Research (ACMRR) of the FAO met in 1969 and drafted a comprehensive scientific report entitled "Global Ocean Research." This report served as a base for IOC preparation in June and approval in September of the Expanded Program outline. To equip itself better to handle its expanded marine science activities and responsibilities, the IOC adopted revised statutes and recommended increases in its level of support. It also decided to accept an appropriate WMO scientific advisory body as an advisory body to the IOC and to establish a group of scientific experts to assist in developing and implementing the Expanded Program.

The IOC also discussed and adopted resolutions concerning other ocean surveys and programs already underway or in planning by—

(1) Adopting a General Plan and Implementation Program of the Integrated Global Ocean Station System (IGOSS)[9] for phase I, and calling for continued U.N. agency support and cooperation for IGOSS;

(2) Endorsing a recommendation by the International Coordination Group for the Cooperative Study of the Kuroshio and Adjacent Regions that a South China Sea Survey be carried out;

(3) Accepting reports of the Coordination Group for the Cooperative Investigation of the Caribbean and Adjacent Regions (CICAR);

(4) Calling for further work by its International Coordination Group for the Southern Ocean and of the Joint Coordination Group on cooperative Systematic Studies in the North Atlantic; and

(5) Adopting in principle the proposed Cooperative Investigations on the Northern Part of the Eastern Central Atlantic (CINECA) to be implemented in cooperation with the International Council for the Exploration of the Seas (ICES) and FAO.

The IOC continued its efforts to promote fundamental scientific research in the oceans by reducing impediments to oceanographic research. In particular it sought to reduce restraints imposed by coastal states on oceanographic research off their shores stemming largely from concern about potential development of ocean or continental shelf resources. The IOC Working Group on Legal Questions Related to Scientific Investigation of the Ocean prepared a draft resolution designed to assist scientists in obtaining research vessel clearances for scientific research. After discussion and modification the resolution was adopted by the IOC in 1969. Also the IOC continued preparatory work on a convention which would regularize the

[9] IGOSS is contemplated as a worldwide system for observing the marine environment, communicating and processing the data, and disseminating the products in 'real time' for use by marine interests. IGOSS would be closely related to and coordinated with the World Weather Watch programs.

In September 1969, the Intergovernmental Oceanographic Commission adopted the first phase plan and implementation program for the Integrated Global Ocean Station System (IGOSS) prepared by the second joint meeting, seen here, of the IOC Working Committee for IGOSS and the WMO Executive Committee Panel on Meteorological Aspects of Ocean Affairs.

legal status of ocean data acquisition systems (ODAS), or instrumented research buoys.

In the field of marine meteorology the WMO Executive Committee Panel on the Meteorological Aspects of Ocean Affairs met in 1969, convened with the IOC Working Group on IGOSS, and reported to the WMO Executive Committee. The WMO gave particular attention to the integration of the IGOSS program with the World Weather Watch.

In the field of marine pollution, a Joint IMCO, FAO, UNESCO, WMO Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) was established in 1969 to advise the sponsoring organizations and the IOC on the scientific and technical aspects of marine pollution problems. This group plans to develop and propose joint programs of action in marine pollution. GESAMP may also provide, on request, specialized advice to governments in cases of incidents involving marine pollution.

The Intergovernmental Maritime Consultative Organization (IMCO) met in 1969 and adopted a number of amendments to the 1960 Convention on Safety of Life at Sea pertaining to safety equipment aboard ships. IMCO also adopted a number of amendments to the Convention on Prevention of Pollution of the Sea by Oil of 1954. The IMCO Assembly called for convening an international conference in 1973 on Marine Pollution and an international conference on revision of the Rules for Prevention of Collision at Sea in 1972. Under the auspices of IMCO the International Legal Conference adopted two conventions in November dealing with the legal prob-

lems of marine pollution by oil. One convention deals with the right of a coastal State to take action on the high seas against a vessel that is polluting or in danger of polluting by oil; the other convention deals with liability of tanker owners for pollution damage by oil to a coastal State or coastal victims.

The Food and Agriculture Organization (FAO) supports a broad range of fishery projects in developing countries, far exceeding the scope of similar projects supported through bilateral and other multilateral channels. The extent of the U.S. contribution to these FAO projects is indicated in table XIII–1.

The U.N. Economic Commission for Asia and the Far East (ECAFE) continued its investigations of the Continental Shelves of four East Asian nations, including surveys carried out with the assistance of U.S. Navy ships and aircraft as part of the Navy's worldwide survey program. In addition, initial steps were taken to establish a separate coordinating committee for offshore prospecting in areas bordering the Indian Ocean.

Improving International Fisheries Arrangements

The basic international fisheries policy of the United States is to encourage expanded and more rational use of the living resources of the sea for the benefit of mankind. To this end, the United States seeks to insure the basic freedoms of the seas, including the freedom of fishing, subject to the limitations of sound conservation principles and the need to protect and harmonize the particular interests of nations and of competing groups of fishermen. The United States has strengthened its commitment to the use of tested mechanisms of international cooperation in fisheries, such as the international fisheries commissions and multilateral and bilateral agreements, for conserving resources and avoiding conflict among fishermen of different nations.

The United States actively participates in nine international fisheries commissions as listed in table XIII–2. These commissions carry out or coordinate research on the biology and ecology of fishery stocks which yield an aggregate annual harvest to the U.S. industry valued at about $300 million at the fishermen's level. In keeping with its commitment to finding cooperative solutions to international fishery problems, the United States has joined in bilateral fishery agreements with a number of countries and is engaged in negotiating additional agreements. Among the significant developments in 1969 within the commissions and bilateral arrangements to which it is a party, the United States—

(1) Renewed agreements with Japan and signed new agreements with the U.S.S.R. concerning fishing activities, fishing gear conflicts in the northeastern Pacific, and king crab fishing and cooperative fishery research in the Bering Sea;

(2) Signed an agreement with Poland on conserving fish stocks and protecting the interests of U.S. commercial and sport fishermen off the Middle Atlantic coast;

(3) Agreed to new arrangements with the U.S.S.R. covering fisheries of the Middle Atlantic region, including cooperative fisheries research projects;

Table XIII-2—U.S. Contributions to International Fisheries Commissions

International fishery commissions	Percent supported by U.S.	Contributions: Fiscal year 1969	Fiscal year 1970	President's budget fiscal year 1971	Approximate value of U.S. 1968 catch at fishermen's level
	Percent	*Thousands*	*Thousands*	*Thousands*	*Millions*
International Pacific Halibut Commission	50	$206	$214	$260	$4
International Pacific Salmon Commission	50	377	386	406	2
Inter-American Tropical Tuna Commission	96	416	427	492	48
International Commission for the Northwest Atlantic Fisheries	7	6	7	7	137
International Whaling Commission	6	1	1	1	1
Great Lakes Fishery Commission	68	1,029	1,319	1,352	6
International North Pacific Fisheries Commission	33	23	23	23	96
North Pacific Fur Seal Commission	25	5	4	4	4
International Commission for the Conservation of Atlantic Tuna [1]	13	....	10	10	3
Total		2,063	2,391	2,555	301

[1] Includes small amount for travel expenses of U.S. Commissioners and their advisers.

(4) Joined in the entry into force of the International Convention for the Conservation of Atlantic Tunas and participated in the first meeting of the Commission established by the Convention;

(5) Participated in formulating proposals by the International Commission for the Northeast Atlantic Fisheries for measures to conserve the North Atlantic salmon and the endangered haddock and hake stocks of the northwestern Atlantic;

(6) Joined in recommending a substantial increase, for the second consecutive year, in the catch quota for Eastern Pacific yellow-fin tuna;

(7) Shared in improving arrangements for effective conservation of North Pacific whales and lowering the catch quota for Antarctic whales to a more rational level;

(8) Participated in extending the North Pacific Fur Seal Convention for an additional 6 years;

(9) Initiated negotiations with the Government of the Bahama Islands for U.S. spiny lobster fishermen to continue their traditional fishing and cooperation in conservation of the resource;

(10) Ratified the Convention on Conduct of Fishing Operations in the North Atlantic, providing for good order on the fishing grounds under international enforcement and for reduction of pollution by fishing vessels;

(11) Contributed to intensified measures to eradicate the predatory sea lamprey in Lake Huron;

(12) Joined with other nations in two Protocols to the International Convention for the Northwest Atlantic Fisheries which entered into force, providing for international enforcement and more expeditious implementation of conservation regulations; and

(13) Initiated discussions with Chile, Ecuador, and Peru to seek an agreement to resolve the longstanding problem of seizures of U.S. fishing vessels by those countries and to promote cooperation among the four nations in fisheries research, development, and conservation.

Fostering Multilateral, Regional, and Bilateral Cooperation

Marine science and technology offer numerous opportunities for international cooperation which can strengthen scientific and economic growth and promote multilateral, regional and bilateral cooperation. The United States is fostering such cooperation through its marine science program, through various multilateral and regional programs and through activities of the U.N. family of organizations. International cooperative programs concerning the Great Lakes are discussed in chapter III.

Federal agencies support several hundred projects involving bilateral cooperation and a wide range of multilateral activities ranging from accommodating foreign oceanographers on U.S. research ships and in U.S. laboratories to U.S. participation in the Pacific tsunami warning system, broad exchange of weather information, conduct of the International Ice Patrol, and collection and distribution of hydrographic data and charts. The Council's Executive Secretary visited Brazil, Venezuela, Mexico, Canada and France during 1969 to discuss U.S. Government marine science plans and programs.

The United States has bilateral science arrangements with France and Japan. Cooperation with the French in marine sciences was initiated in 1969 through an informal joint program coordinated by the Marine Sciences Council and the French National Center for the Exploitation of the Oceans (CNEXO). Within this framework five areas of mutual interest were developed in technology of deep diving, buoy technology, ocean pollution, research personnel training and fish protein concentrate. Contacts between the responsible U.S. agencies and French specialists were established, program and priority information exchanged, and an attempt to identify specific collaborative projects initiated. The Council's Executive Secretary held discussions with CNEXO's Secretary General which resulted in steps to expand the cooperative program.

The United States-Japanese Cooperative Program in Natural Resources Development established in 1964, has been expanded to include marine sciences. During 1969 marine science panels were designated and panel and committee membership selection initiated.

Among other 1969 highlights in international cooperative efforts:

1. Foreign scientists—Australian, Brazilian, British, French, Italian, New Zealand, Swiss, and Soviet—participated in the drilling and coring opera-

tions of the deep-drilling ship *Glomar Challenger,* administered by the National Science Foundation.

2. The United States participated in the trade exhibit, Oceanology International '69 in Brighton, England.

3. United States (ESSA), German and British scientists and ships joined in the successful Atlantic Tradewind Experiment (ATEX) to investigate air and sea interaction in the equatorial Atlantic.

4. Scientists from several nations participated in the field phase of the major air and sea interaction program of Barbados Oceanographic and Meteorological Experiment (BOMEX), led by ESSA.

5. The National Oceanographic Data Center (NODC) continued a useful exchange of data with the World Data Center system and foreign data centers and international organizations. Over 75 percent of oceanographic stations held by NODC yielding classical physical-chemical data come from foreign sources.

6. The Navy's harbor survey assistance program (HARSAP) for collecting charting data and training nationals in conducting hydrographic surveys and producing charts completed surveys of ports in Costa Rica, the Dominican Republic, Nicaragua, and El Salvador and continued work in Honduras and Costa Rica; and

7. The Bureau of Commercial Fisheries, the Scripps Institution of Oceanography and the Soviet Far Eastern Seas Fishery Institute cooperatively surveyed Pacific hake populations off the U.S. west coast.

In 1969, the North Atlantic Treaty Organization (NATO) pursued several marine science objectives. In addition to the continued activities of the NATO Science Committee's Ad Hoc Study Group on Oceanography, the NATO Ministers in their December meeting in Brussels acknowledged the work in progress on arms control of the seabed and the role the Alliance might play in dealing with common environmental problems of modern societies. They cited the possibility of further cooperation with Warsaw Pact governments in oceanography, which could be pursued bilaterally, multilaterally or in the framework of existing international bodies.

Future Opportunities

International cooperation in the oceans has existed for many years. But the pace and scope of cooperative international activities is increasing. In the years ahead present initiatives will be implemented and new opportunities sought.

Seabed arms control measures will have to be completed; multilateral development of legal arrangements to prevent conflicts in the ocean and on the seabed must continue; the International Decade of Ocean Exploration must be carried out as a major oceanic exploration and research cooperative program; efforts to provide the benefits of new marine technology for developing nations must be increased; and closer ties between nations in marine science collaboration will have to be forged. The opportunities for international cooperation in the oceans have never been better; the needs for such cooperation have never been greater.

Chapter XIV

INTERNATIONAL DECADE OF OCEAN EXPLORATION

In 1969, the United States formally announced its initial plans for participation in the International Decade of Ocean Exploration, culminating 2 years of intensive planning in national and international forums; and the international community moved ahead in outlining and shaping the multinational framework for planning and coordination.

The United States had proposed the International Decade in March 1968 as a program of intensified international collaboration to plan, develop, and carry out research to increase understanding of the ocean and its mineral and living resources. Later in the year the United Nations General Assembly welcomed the proposal as an important element of a United Nations Long Term and Expanded Program of Oceanic Exploration and Research.

The Decade concept anticipates sustained international planning and coordination to identify the most promising geographic areas and lines of scientific and engineering inquiry, set priorities, and agree on the sharing and distribution of effort. It is oriented toward learning more about the ocean environment, and places new emphasis on standardized data collection and dissemination techniques, expanded involvement of a large number of nations, and stronger coordination among the many international bodies concerned with the sea.

On October 19 the Vice President announced the initial U.S. Decade plans, as one of the areas of the President's five-point marine science program, stating that the United States would propose international emphasis on goals to—

(1) Preserve the ocean environment by accelerating scientific observations of the natural state of the ocean and its interactions with the coastal margin—to provide a basis for (*a*) assessing and predicting man-induced and natural modifications of the character of the oceans; (*b*) identifying damaging or irreversible effects of waste disposal at sea; and (*c*) comprehending the interaction of various levels of marine life to permit steps to prevent depletion or extinction of valuable species as a result of man's activities;

(2) Improve environmental forecasting to help reduce hazards to life and property and permit more efficient use of marine resources—by improving physical and mathematical models of the ocean and

The research vessel Atlantis II *lies at anchor off the Malagasy Republic. International cooperation in scientific research will lead to a greater understanding of the world ocean during the International Decade of Ocean Exploration.*

atmosphere which will provide the basis for increased accuracy, timeliness, and geographic precison of environmental forecasts;

(3) Expand seabed assessment activities to permit better management—domestically and internationally—of marine mineral exploration and exploitation by acquiring needed knowledge of seabed topography, structure, physical and dynamic properties, and resource potential, and to assist industry in planning more detailed investigations;

(4) Develop an ocean monitoring system to facilitate prediction of oceanographic and atmospheric conditions—through design and deployment of oceanographic data buoys and other remote sensing platforms;

(5) Improve worldwide data exchange through modernizing and standardizing national and international marine data collection, processing, and distribution; and

(6) Accelerate Decade planning to increase opportunities for international sharing of responsibilities and costs for ocean exploration, and to assure better use of limited exploration capabilities.

These U.S. proposals are compatible with the outline of the program developed by the Intergovernmental Oceanographic Commission and discussed in the preceding chapter. The National Science Foundation has been assigned initial, lead agency responsibility for the planning and coordination of the U.S. contribution to the Decade. Federal funding of $15 million is being requested for Decade programs in the fiscal year 1971 budget. In addition many ongoing federally funded ocean exploration and research activities are related to the Decade. The extent and nature of future U.S. contributions will depend on the participation of other nations in the Decade program.

Evolution of U.S. Plans for the Decade

In the United States, planning for the Decade began in 1968.[1] The Marine Sciences Council was then assigned responsibility for coordinating the Decade program on a Government-wide basis. The proposal was elaborated in the Council's report "International Decade of Ocean Exploration" in May 1968.

In July 1968, the Council contracted for the National Academy of Sciences and the National Academy of Engineering to prepare recommendations concerning the scientific and engineering aspects of the Decade. More than 50 of the Nation's foremost ocean scientists and engineers participated in this study, "An Oceanic Quest," which was released in May 1969. The Council supported a study by the Gulf Universities Research Corporation (GURC), "Gulf of Mexico: Model for the Decade," and a number of proposals were prepared by scientific groups in the United States and abroad. In its report, "Our Nation and the Sea," the Commission on Marine Science, Engineering and Resources strongly endorsed the concept of an International Decade of Ocean Exploration.

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[1] A report, in detail on initial U.S. planning for the Decade was presented in ch. IX of the Council's third annual report, "Marine Science Affairs—A Year of Broadened Participation," January 1969.

In the Congress, House Concurrent Resolution 57 and Senate Concurrent Resolution 23 were introduced in 1969 setting forth objectives and expectations of the Decade.[2]

At its meeting on May 23, 1969, the Marine Sciences Council received a report on the Decade from a special Council task force and directed that accelerated governmental planning be undertaken to define specific Decade programs that would deserve highest priority during fiscal years 1971–74.

In response to the Council's request for explicit program recommendations, an Interagency Decade Planning Group was formed and staffed by the Council Secretariat. The group developed preliminary Decade planning methodology; evaluated 150 Decade-related proposals including proposals by the academies, GURC, international scientific bodies, Federal agencies, Council staff, and individual U.S. scientists and engineers; identified the base of ongoing federally funded Decade-related activities; defined goals and objectives; and recommended general goals with priority program elements consistent with the objectives of the IOC proposed outline. The program recommendations were formally reviewed by the Council's Committee for Policy Review in September, and the administration announced plans to proceed with the Decade in October.

International Preparation for the Decade

The international commitment to an International Decade of Ocean Exploration was realized in U.N. General Assembly Resolution 2467 D (XXIII), proposed by the United States and adopted on December 21, 1968. General Assembly Resolution 2414 (XXIII) also endorsed the concept of a long-term and expanded program of oceanographic research including the Decade. The intergovernmental planning phase of the Expanded Program and Decade began in June 1969 when a 17-nation Working Group of the IOC prepared a draft comprehensive outline of the scope of the U.N.'s long-term program of oceanic research, in accordance with the U.N. resolution identifying the IOC as a focal point for planning. The Working Group proposed that the Decade would be the acceleration phase of the long-term program. The U.N. Seabeds Committee favorably considered the comprehensive outline in August, and in September it was formally approved by the IOC. It was considered favorably by ECOSOC and the Twenty-fourth Session of the U.N. General Assembly in the fall.

In 1970, the IOC will seek to adopt internationally agreed objectives for the program and begin to seek international agreements on specific program elements that will contribute to achieving these objectives. Initially, proposals will be considered by the IOC Group of Experts on Long-Term Scientific Policy and Planning, established by the IOC at its meeting in Paris in January 1970 to develop the international scope and content of the Expanded Program.

Three developments have heightened international interest in ocean exploration and research.

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[2] The resolutions are included in app. B–4.

1. The world's growing population, together with intensified industrialization and urban concentration, has sharply increased the demand for food, energy, and minerals, enlarged worldwide ocean-borne resources distribution networks, and increased the quantity of waste products deposited in the ocean, thus threatening the environment, especially of inshore areas.

2. New marine technology is making possible increased operations in the sea, once inaccessible because of the ocean's hostile environment, thus opening possibilities for greater use of ocean resources.

3. More than 100 independent nations face the sea, and many hope that new developments in ocean technology will enable them to obtain greater benefits from ocean resources. This heightened international interest has increased the possibility of overlapping interests between nations and depletion of marine resources, and has spurred consideration of seaward extensions of national jurisdiction.[3]

Benefits of the Decade

The knowledge which will evolve during the Decade will assist nations individually to plan ocean related investments and collectively to develop arrangements for managing ocean resources, to establish baselines as a step toward preserving the quality of the oceanic environment, and to improve forecasting of ocean and weather conditions. Because of the global character of the oceans and the scope of the work to be done, international cost sharing by cooperative exploration and data exchange can benefit all participating nations.

The enhanced ocean uses and resource potential can provide benefits to developing nations. Unused fishery resources and fuel mineral deposits exist off the coasts of a number of developing countries. Many are dependent upon maritime transportation to link coastal communities and provide the basis for foreign trade. The Expanded Program will give special emphasis to broadening the opportunities for developing nations to participate in the use of the oceans and its resources through encouraging them, for example, to map selected areas of the Continental Shelves, survey coastal fishery resources, and obtain training and experience in marine sciences and engineering.

With regard to ocean resources, the ultimate development of worldwide petroleum and solid mineral potential to benefit all nations depends in large measure on the extent of seabed exploration, and on the soundness of national and international resource management policies which should be based on knowledge of the character of the resources. Offshore petroleum and gas in 1985 is expected to meet 30 percent of the world's total energy demand.

The oceans contain large unused fishery resources and fisheries offer an opportunity to assist in closing the protein gap with many latent fisheries lying within easy access of nations plagued by serious protein deficiencies.

[3] Ch. XIII discusses a number of developments in 1969 which reflect the growing international interest and activity.

The pooling of knowledge about these resources by interested nations during the Decade could contribute significantly to development and management of world fisheries resources.

More accurate, timely, and long-range forecasts of climate and weather conditions, storms, waves, ice, tidal waves, coastal surf and currents, storm surges, floods, and ocean temperatures will benefit expanding commercial and recreational marine activities; reduce the destruction of life and property in the coastal zone and at sea; and enhance industry, agriculture, water management, and other land activities dependent on a better understanding of the interactions between the oceans and the atmosphere. Recurring hurricane devastation in the southeast and gulf coasts of United States has underscored the importance of accurate and timely environmental forecasts.

The oceans also serve as a unique scientific laboratory. Effective exploration of the oceans is best achieved through balanced research and surveys—between programs to solve specific scientific problems and programs for systematic collection of data on a geographical base. Such patterns of accelerated ocean investigation will result in advancement of science on a broad front as we expand our knowledge of the geology and geophysics of the ocean basins, the interaction of living organisms, and the ecology of the marine environment. This knowledge can be usefully applied in all nations' evolving oceanic activities.

The Decade does not contemplate exploration of every square mile of the world's ocean nor investigation of every conceivable ocean phenomenon. But it emphasizes that, collectively, the nations of the world can identify the most promising geographical areas and lines of scientific inquiry, and by careful selection focus emphasis on inquiries of greatest promise. The implementation of this major international undertaking in 1970 marks a significant step forward in international cooperative use of the world ocean.

APPENDICES

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAM, FISCAL YEARS 1969, 1970, AND 1971

Appendix A-1—Federal Marine Science Program [a] by Department and Independent Agency

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
Department of Defense [b] [c]	259.7	263.8	239.7
Department of the Interior [d]	80.8	98.5	95.0
National Science Foundation	34.9	40.7	63.0
Department of Commerce	38.1	49.2	58.9
Department of Transportation	19.8	31.3	[e] 42.6
Atomic Energy Commission	10.6	10.0	9.7
Department of Health, Education, and Welfare	7.3	7.0	9.0
Department of State	6.9	7.7	8.4
Agency for International Development	1.5	2.6	2.6
Smithsonian Institution	1.9	1.9	2.4
National Aeronautics and Space Administration	1.9	1.8	1.8
Total	463.4	514.5	533.1

[a] Many programs of the Departments of Defense, Commerce, Interior, and Transportation, and other agencies closely related to marine sciences, are not included.

[b] Totals include for the first time ARPA's Advanced Surface Platforms Program ($1.9, $6.0, and $12.3 million for the respective years).

[c] Excludes development of the Navy's Surface Effects Ships Program ($3.3, $7.9, and $20 million in the respective years).

[d] Totals include for the first time marine research supported by the Office of Water Resources Research ($0.5, $0.9, and $1.1 million for the respective years).

[e] Does not include new $59 million replacement icebreaker which will have oceanographic research capabilities.

Note: The totals for fiscal years 1970 and 1971 differ slighty from those published at the time the President's Budget was released in February due to subsequent Department of the Navy internal re-allocations which affected the Navy's budget for designated marine science efforts.

Appendix A-2—Federal Marine Science Program [a] by Major Purpose—Summary and Detail by Subpurpose and Agency

Summary

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
1. International Cooperation and Collaboration...	8. 4	10. 3	11. 0
2. National Security	127. 2	129. 1	116. 1
3. Fishery Development and Seafood Technology..	45. 3	52. 2	45. 6
4. Transportation	16. 7	29. 6	40. 9
5. Development of the Coastal Zone	32. 1	40. 7	45. 7
6. Health	6. 0	5. 9	8. 2
7. Non-Living Resources	8. 0	9. 2	9. 2
8. Oceanographic Research [b]	78. 4	82. 5	108. 2
9. Education	6. 7	8. 4	8. 2
10. Environmental Observation and Prediction....	33. 7	31. 7	32. 8
11. Ocean Exploration, Mapping, Charting and Geodesy	79. 7	89. 4	74. 7
12. General Purpose Ocean Engineering	19. 1	22. 8	29. 5
13 National Data Centers	2. 2	2. 7	3. 0
Total	463. 4	514. 5	533. 1

[a] Many programs of the Departments of Defense, Commerce, Interior and Transportation and other agencies closely related to marine science are not included. Programs supported by ARPA on advanced surface platforms and by Interior's Office of Water Resources Research on marine research are included for the first time.

[b] Research beneficial to more than one of the other major purpose categories.

Note: The totals for fiscal years 1970 and 1971 differ slightly from those published at the time the President's Budget was released in February due to subsequent Department of the Navy internal reallocations which affected the Navy's budget for designated marine science efforts.

Detail by Subpurpose and Agency

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
1. International Cooperation and Collaboration...	8. 4	10. 3	11. 0
(a) State Department	(6. 9)	(7. 7)	(8. 4)
(1) Contributions to international organizations for marine science program activities..	4. 8	5. 3	5. 8
(2) International fisheries commissions (U.S. share)	2. 1	2. 4	2. 6
(b) Agency for International Development	(1. 5)	(2. 6)	(2. 6)
(1) Marine food resources for developing nations	1. 5	2. 6	2. 6

Appendix A–2—Continued

Detail by Subpurpose and Agency—Continued

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
2. National Security	127. 2	129. 1	116. 1
(a) Department of Defense [a]	(127. 2)	(129. 1)	(116. 1)
(1) Problem oriented surveys for defense systems	22. 4	22. 7	18. 9
(2) Marine science and technology in support of specific defense systems	36. 1	34. 7	39. 8
(3) Undersea search, rescue, recovery, and man-in-the-sea	65. 7	63. 3	36. 0
(4) Navy Instrumentation Center	0. 9	1. 7	1. 8
(5) Capital investment for ship construction	0	0	7. 3
(6) Marine science in support of "safeguards" for the Limited Nuclear Test Ban Treaty of 1963	0. 2	0. 7	0
(7) Advanced Surface Platforms [b]	1. 9	6. 0	12. 3
3. Fishery Development and Sea Food Technology	45. 3	52. 2	45. 6
(a) Department of the Interior	(45. 3)	(52. 2)	(45. 6)
(1) Fishery resources assessment, development and management	33. 4	36. 8	32. 8
(2) Technical and economic assistance to the commercial fishing industry	9. 3	11. 7	9. 9
(3) Fish protein concentrate	2. 6	3. 7	2. 9
4. Transportation	16. 7	29. 6	40. 9
(a) Department of Commerce [c]	(9. 2)	(16. 6)	(23. 2)
(1) Maritime science and technology	0. 7	2. 7	6. 2
(2) Shipping economics and requirements	1. 0	2. 4	3. 7
(3) Advanced ship engineering and development	7. 0	9. 8	10. 6
(4) Improvements in ship operations and shipping systems	0. 5	1. 7	2. 7
(b) Department of Defense	(2. 7)	(2. 9)	(4. 1)
(1) Channel and harbor development	2. 7	2. 9	4. 1
(c) Department of Transportation	(4. 8)	(10. 1)	(13. 6)
(1) Search and rescue	0. 2	0. 6	1. 2
(2) Aids to navigation	0. 9	1. 0	2. 2
(3) Merchant marine safety	0. 9	0. 5	1. 1
(4) Oceanography, meteorology, and polar operations	0. 6	0. 7	[d] 0. 8
(5) Marine law enforcement	2. 2	7. 3	8. 3

See footnotes at end of table.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAM, FISCAL YEARS 1969, 1970, AND 1971—Continued

Appendix A-2—Continued

Details by Subpurpose and Agency—Continued

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
5. Development and Conservation of the Coastal Zone	32. 1	40. 7	45. 8
(a) Shore stabilization and protection	(1. 5)	(1. 5)	(2. 1)[a]
(1) Department of Defense:			
a. Beach erosion control and hurricane storm surge protection	1. 5	1. 5	2. 1
(b) Marine pollution management	(11. 9)	(19. 8)	(19. 8)
(1) Department of Defense	((2. 2))	((1. 6))	((2. 2))
a. Pollution and flushing of bays, estuaries and the Great Lakes	2. 2	1. 6	2. 2
(2) Department of the Interior	((9. 7))	((18. 2))	[e] ((17. 6))
a. Water quality enhancement	9. 7	18. 2	17. 6
(c) Recreation and conservation	(18. 7)	(19. 4)	(23. 9)
(1) Department of Defense	((1. 5))	((1. 4))	((2. 0))
a. Recreation beaches and small craft harbors	1. 5	1. 4	2. 0
(2) Department of the Interior	((17. 1))	((17. 8))	((21. 3))
a. Planning for acquisition of marine based recreational areas	0. 1	0. 1	0. 1
b. Development of marine areas for recreation	7. 6	8. 0	10. 4
c. Conservation of marine locales, gamefish and wildlife	9. 4	9. 7	10. 8
(3) Department of Transportation	((0. 1))	((0. 2))	((0. 6))
a. Search and rescue	0. 1	0. 2	0. 6
6. Health	6. 0	5. 9	8. 2
(a) Department of Health, Education, and Welfare	(6. 0)	(5. 9)	(8. 2)
(1) Nutritional and health aspects of marine foods	2. 5	2. 5	3. 6
(2) Marine bacterial toxins and pharmaceuticals	1. 2	1. 2	2. 1
(3) Use of marine life in biomedical research	2. 2	2. 1	2. 4
(4) Health problems related to marine pollution	0. 1	0. 1	0. 1

See footnotes at end of table.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAM, FISCAL YEARS 1969, 1970, AND 1971—Continued

Appendix A–2—Continued

Detail by Subpurpose and Agency—Continued

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
7. Non-Living Resources	8.0	9.2	9.2
(a) Department of the Interior	(8.0)	(9.2)	(9.2)
(1) Geologic investigations and resources appraisal	2.9	3.3	3.3
(2) Mining research	1.5	0.9	0.9
(3) Marine source and interrelationships for supply of fresh water	2.5	3.2	2.8
(4) Leasing and management of mineral resources	1.1	1.8	2.2
8. Oceanographic Research	78.4	82.5	108.2
(a) Department of Defense	34.3	33.2	35.4
(b) Department of Commerce	3.0	3.1	3.9
(c) National Science Foundation	31.1	35.1	[f] 57.1
(d) Department of Transportation	2.3	3.1	2.9
(e) Smithsonian Institution [g]	1.6	1.6	1.9
(f) Atomic Energy Commission	5.6	5.5	5.8
(g) Department of the Interior [h]	0.5	0.9	1.1
9. Education	6.7	8.4	8.2
(a) Department of Defense	1.7	1.8	1.6
(b) Department of Commerce	0.1	0.1	0.1
(c) National Science Foundation	3.5	5.2	5.5
(d) Department of Health, Education, and Welfare	1.3	1.1	0.8
(e) Department of Transportation	0.1	0.2	0.2
10. Environmental Observation and Prediction	33.7	31.7	32.8
(a) Department of Defense	12.1	11.6	11.5
(b) Department of Commerce	7.0	6.7	7.7
(c) Atomic Energy Commission	1.4	1.0	0.8
(d) Department of Transportation	11.7	11.0	11.4
(e) National Aeronautics and Space Administration	1.5	1.4	1.4
11. Ocean Exploration, Mapping, Charting, and Geodesy	79.7	89.4	74.7
(a) Department of Defense	60.7	66.7	50.7
(b) Department of Commerce	18.5	22.3	23.6
(c) National Aeronautics and Space Administration	0.4	0.4	0.4

See footnotes at end of table.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAM, FISCAL YEARS 1969, 1970, AND 1971—Continued

Appendix A-2—Continued

Details by Subpurpose and Agency—Continued

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
12. General Purpose Ocean Engineering	19. 1	22. 8	29. 5
(a) Department of Defense:			
(1) Deep ocean technology	14. 8	13. 0	12. 9
(b) Atomic Energy Commission:			
(1) Nuclear power	3. 6	3. 5	3. 1
(c) Department of Transportation:			
(1) Data buoy systems	0. 7	6. 3	13. 5
13. National Data Centers	2. 2	2. 7	3. 0
(a) National Oceanographic Data Center	1. 6	2. 1	2. 1
(b) Smithsonian Oceanographic Sorting Center	0. 3	0. 3	0. 5
(c) Great Lakes Data Center	0. 2	0. 2	0. 3
(d) National Weather Records Center	0. 1	0. 1	0. 1

[a] All Department of Defense funds primarily relate to National Security although they may appear in categories which are related to other national goals.
[b] Included in the marine sciences program for the first time. Funds support exploratory development by the Advanced Research Projects Agency of a surface effects vehicle for the Arctic and a large floating platform.
[c] The scope of the program is the same as last year, but the reporting subcategories are renamed.
[d] Does not include $59 million replacement Coast Guard icebreaker which will have oceanographic capabilities.
[e] Includes $1 million for FWPCA in support of Pilot Lake Restoration Project.
[f] Includes $15 million to support initial programs of the International Decade of Ocean Exploration and $1.2 for marine-related Arctic environmental research, in accordance with NSF lead-agency responsibilities in these areas.
[g] Appropriated Excess Foreign Currency Funds not included herein are also used to support marine science (app. A-7).
[h] New inclusion in marine sciences program. Funds obligated by the Office of Water Resources Research or coastal zone and estuarine research.

Appendix A-3—Federal Marine Science Program by Function—Summary and Detail by Agency

Summary

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
Research and Development	265. 7	299. 5	337. 4
(a) Research (basic and applied)	131. 7	155. 5	182. 8
(Ship operating costs)	(22. 1)	(21. 7)	(21. 9)
(b) Development of new equipment and technology	134. 0	144. 0	154. 6
(Ship operating costs)	(7. 3)	(7. 8)	(8. 3)

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAM, FISCAL YEARS 1969, 1970, AND 1971—Continued

Appendix A-3—Continued

Summary—Continued

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
Investment	49.7	63.7	42.6
(a) Ships	2.0	0	7.3
(b) Major equipment	32.5	43.5	19.0
(c) Shore facilities	12.1	15.4	11.5
(d) Other	3.1	4.8	4.8
Operations	148.0	151.3	153.1
(a) Surveys	115.2	113.9	113.4
(Ship operating costs)	(41.3)	(37.7)	(39.3)
(b) Services	24.1	27.2	28.6
(Service ship operating costs)	(0.3)	(0.3)	(0.3)
(c) Other operations	8.7	10.2	11.1
Total	463.4	514.5	533.1

Detail by Agency

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
A. Research and Development			
Total	265.7	299.5	337.4
1. Department of Defense	144.7	143.7	141.5
(a) Department of the Navy	(133.1)	(125.6)	(112.6)
(1) Research	33.5	30.1	30.4
(Research ship operating costs)	((5.3))	((5.0))	((5.6))
(2) Development of new equipment and technology	99.6	95.5	82.2
(Ship operating costs)	(7.3)	(7.8)	(8.3)
(b) Department of the Army	(8.7)	(8.3)	(11.6)
(1) Research	3.5	3.4	4.8
(2) Development of new equipment and technology	5.2	4.9	6.8
(c) Advanced Research Projects Agency	(2.9)	(9.8)	(17.3)
(1) Research	0.8	3.1	5.0
(2) Development of new equipment and technology [a]	2.1	6.7	12.3

See footnotes at end of table.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAM, FISCAL YEARS 1969, 1970, AND 1971—Continued

Appendix A-3—Continued

Detail by Agency—Continued

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
A. Research and Development—Continued			
2. Department of Commerce	14. 6	21. 7	29. 0
(a) Environmental Science Services Administration	(5. 4)	(5. 7)	(6. 5)
(1) Research	3. 5	3. 8	4. 6
(2) Development of new equipment and technology	1. 9	1. 9	1. 9
(b) Maritime Administration	(9. 2)	(16. 0)	(22. 5)
(1) Research	4. 3	10. 7	11. 9
(2) Development of new equipment and technology	4. 9	5. 3	10. 6
3. Department of the Interior	40. 6	52. 7	50. 4
(a) Bureau of Commercial Fisheries	(28. 0)	(31. 1)	(29. 2)
(1) Research	23. 4	25. 8	24. 1
(Research ship operating costs)	2. 8	3. 0	2. 7
(2) Development of new equipment and technology	4. 6	5. 3	5. 1
(b) Geological Survey	(2. 8)	(3. 0)	(3. 1)
(1) Research	2. 8	3. 0	3. 1
(Research ship operating costs)	(0. 2)	(0. 2)	(0. 2)
(c) Office of Saline Water	(2. 1)	(2. 8)	(2. 4)
(1) Research	0. 7	0. 9	0. 9
(2) Development of new equipment and technology	1. 4	1. 9	1. 5
(d) Bureau of Sport Fisheries and Wildlife	(2. 0)	(1. 9)	(2. 9)
(1) Research	2. 0	1. 9	2. 9
(e) Office of Water Resources Research [b]	(0. 5)	(0. 9)	(1. 1)
(1) Research	0. 5	0. 9	1. 1
(f) Bureau of Mines	(1. 1)	(0. 9)	(0. 8)
(1) Research	0. 5	0. 7	0. 5
(Research ship operating costs)	(0. 4)	(0)	(0. 1)
(2) Development of new equipment and technology	0. 6	0. 2	0. 3
(g) Federal Water Pollution Control Administration	(4. 1)	(12. 1)	(10. 9)
(1) Research	4. 1	12. 1	10. 9
4. National Science Foundation	33. 2	40. 1	[c] 62. 2
(1) Research	33. 2	40. 1	62. 2
(Research ship operating costs)	(10. 9)	(9. 9)	(9. 9)

See footnotes at end of table.

Appendix A-3—Continued

Detail by Agency—Continued

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
A. Research and Development—Continued			
5. Atomic Energy Commission	10. 6	10. 0	9. 7
(1) Research	7. 9	6. 5	6. 6
(Research ship operating costs)	(0. 3)	(0. 3)	(0. 3)
(2) Development of new equipment and technology	3. 6	3. 5	3. 1
6. Department of Health, Education, and Welfare	5. 3	4. 9	5. 1
(a) Consumer Protection and Environmental Health Services	(1. 4)	(1. 2)	(1. 7)
(1) Research	1. 4	1. 2	1. 7
(b) National Institutes of Health	(2. 6)	(2. 6)	(2. 6)
(1) Research	2. 6	2. 6	2. 6
(c) Office of Education	(1. 3)	(1. 1)	(0. 8)
(1) Research	1. 3	1. 1	0. 8
7. Department of Transportation	6. 4	15. 3	27. 4
(1) Research	3. 1	4. 2	5. 0
(Research ship operating costs)	(2. 2)	(3. 3)	(3. 1)
(2) Development of new equipment and technology	3. 3	11. 0	22. 4
8. Smithsonian Institution	1. 6	1. 6	1. 9
(1) Research	1. 6	1. 6	1. 9
9. State Department	6. 9	7. 7	8. 4
(1) Development of new equipment and technology	6. 9	7. 7	8. 4
10. National Aeronautics and Space Administration	1. 9	1. 8	1. 8
(1) Research	1. 9	1. 8	1. 8
B. Investment			
Total	49. 7	63. 7	42. 6
1. Department of Defense	36. 2	42. 3	25. 3
(a) Department of the Navy	(35. 9)	(42. 1)	(25. 0)
(1) Ships (new construction of surface ships)	0	0	7. 3
(2) Major equipment	31. 3	39. 0	15. 0
(3) Shore facilities	4. 6	3. 1	2. 7
(b) Department of the Army	(0. 3)	(0. 2)	(0. 3)
(1) Shore facilities	0. 3	0. 2	0. 3

See footnotes at end of table.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAM, FISCAL YEARS 1969, 1970, AND 1971—Continued

Appendix A-3—Continued

Detail by Agency—Continued

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
B. Investment—Continued			
2. Department of Commerce	0.3	3.8	2.5
(a) Environmental Science Services Administration	(0.3)	(3.2)	(1.8)
(1) Ships	0	0	0
(2) Shore facilities	0	2.5	0
(3) Major equipment	0.3	0.7	1.8
(b) Maritime Administration	0	(0.6)	(0.7)
(1) Shore facilities	0	0.6	0.7
3. Department of the Interior	9.4	11.5	10.0
(a) Bureau of Commercial Fisheries	(2.5)	(4.6)	(1.3)
(1) Shore facilities	2.1	4.2	0.9
(2) Major equipment	0.4	0.4	0.4
(b) Geological Survey	(0.4)	(0.4)	(0.4)
(1) Shore facilities	0.2	0.2	0.2
(2) Major equipment	0.2	0.2	0.2
(c) Bureau of Sport Fisheries and Wildlife	(2.2)	(2.5)	(2.2)
(1) Shore facilities	0.6	0.3	0
(2) Other	1.6	2.2	2.2
(d) Bureau of Mines	(0.4)	0	(0.1)
(1) Ships	0.2	0	0
(2) Shore facilities	0.1	0	0.1
(3) Major equipment	0.1	0	0
(e) Bureau of Outdoor Recreation	(3.9)	(4.0)	(6.0)
(1) Shore facilities	3.9	4.0	6.0
4. National Science Foundation	1.4	0.2	0.4
(1) Ships	1.4	0	0
(2) Shore facilities	0	0.2	0.4
5. Department of Transportation	0.9	3.3	1.8
(a) U.S. Coast Guard	(0.9)	(3.3)	(1.8)
(1) Ships	0.4	0	[d] 0
(2) Major Equipment	0.2	3.2	1.6
(3) Shore facilities	0.3	0.1	0.2
(4) Other	([e])	([e])	([e])
6. Agency for International Development	1.5	2.6	2.6
(1) Other	1.5	2.6	2.6

See footnotes at end of table.

Appendix A-3—Continued

Detail by Agency—Continued

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
C. Operations			
Total	148.0	151.3	153.1
1. Department of Defense	78.8	77.8	72.9
(a) Department of the Navy	(78.6)	(77.6)	(72.6)
(1) Surveys	73.3	72.0	67.2
(Survey ship operating costs)	(20.7)	(17.1)	(16.8)
(2) Services	3.6	3.8	3.8
(3) Other (education)	1.7	1.8	1.6
(b) Department of the Army	(0.2)	(0.2)	(0.3)
(1) Services	0.2	0.2	0.3
2. Department of Commerce	23.2	23.7	27.4
(a) Environmental Science Services Administration	(23.2)	(23.7)	(27.4)
(1) Surveys	22.5	23.0	26.7
(Survey ship operating costs)	((9.6))	((9.8))	((11.4))
(2) Services	0.7	0.7	0.7
3. Department of the Interior	30.8	34.3	34.6
(a) Bureau of Commercial Fisheries	(15.7)	(17.7)	(16.3)
(1) Surveys	5.6	5.6	5.3
(Survey ship operating costs)	((1.1))	((1.3))	((1.3))
(2) Services	10.2	12.1	11.0
(Service ship operating costs)	((0.3))	((0.3))	((0.3))
(b) Geological Survey	(1.1)	(1.8)	(2.1)
(1) Other	1.1	1.8	2.1
(c) Bureau of Sport Fisheries and Wildlife	(5.2)	(5.3)	(5.7)
(1) Surveys	0.7	0.6	0.7
(2) Services	0.1	0	0
(3) Other	4.4	4.7	5.0
(d) Federal Water Pollution Control Administration	(4.7)	(4.9)	(5.5)
(1) Surveys	3.3	3.2	3.7
(2) Services	1.4	1.7	1.8
(e) Bureau of Land Management	(0.3)	(0.5)	(0.5)
(1) Services	0.3	0.5	0.5
(f) National Park Service	(3.8)	(4.1)	(4.5)
(1) Services	3.8	4.1	4.5
4. National Science Foundation	0.3	0.4	0.4
(1) Services	0.3	0.4	0.4

See footnotes at end of table.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAM, FISCAL YEARS 1969, 1970, AND 1971—Continued

Appendix A-3—Continued

Detail by Agency—Continued

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
C. Operations—Continued			
5. Department of Transportation	12. 6	12. 7	13. 4
(a) U.S. Coast Guard	(12. 6)	(12. 7)	(13. 4)
(1) Surveys	9. 9	9. 5	9. 8
(Survey ship operating costs)	((9. 9))	((9. 5))	((9. 8))
(2) Services	1. 2	1. 3	1. 2
(3) Other Operations	1. 5	1. 9	2. 4
6. Smithsonian Institution	0. 3	0. 3	0. 5
(1) Services	0. 3	0. 3	0. 5
7. Atomic Energy Commission:			
(1) Services	(*e*)	(*e*)	(*e*)
8. Department of Health, Education, and Welfare	2. 0	2. 1	3. 9
(a) Consumer Protection and Environmental Health Services	2. 0	2. 1	3. 9
(1) Services	2. 0	2. 1	3. 9

[a] Includes the Advanced Surface Platforms Program not reported in previous years.
[b] Not included in previous years.
[c] Includes $15 million for the International Decade of Ocean Exploration and $1.2 million for an expanded program of Arctic environmental research in accordance with NSF's lead-agency responsibilities for these new initiatives.
[d] The Coast Guard budget includes $59 million for a replacement icebreaker with oceanographic research capabilities which is not included in this marine sciences analysis.
[e] Less than $50,000.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAM, FISCAL YEARS 1969, 1970, AND 1971—Continued

Appendix A-4—Special Analysis: U.S. Continental Shelves (Including Trust Territories)

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
Smithsonian Institution	0. 1	0. 1	0. 2
Department of Commerce	16. 8	17. 2	19. 4
Atomic Energy Commission	4. 1	3. 7	3. 9
Department of Transportation	0. 2	0. 2	0. 2
National Science Foundation	1. 0	1. 5	2. 0
Department of the Interior	27. 3	29. 9	29. 5
1. Bureau of Commercial Fisheries	(17. 4)	(19. 0)	(17. 3)
2. Geological Survey	(3. 2)	(4. 1)	(4. 5)
3. Bureau of Sport Fisheries and Wildlife	(2. 0)	(1. 5)	(2. 2)
4. Bureau of Mines	(1. 2)	(0. 9)	(0. 9)
5. Bureau of Land Management	(0. 3)	(0. 5)	(0. 5)
6. Office of Saline Water	(1. 0)	(1. 4)	(1. 2)
7. National Park Service	(2. 0)	(2. 1)	(2. 4)
8. Office of Water Resources Research	([a])	([a])	([a])
9. Federal Water Pollution Control Administration	(0. 2)	(0. 4)	(0. 5)
Department of Defense	7. 5	7. 5	9. 0
1. Department of the Army	(3. 2)	(3. 0)	(4. 2)
2. Department of the Navy	(4. 3)	(4. 5)	(4. 8)
Total	57. 0	60. 1	64. 2

[a] Less than $50,000.

Appendix A-5—Special Analysis: The Great Lakes

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
Department of Commerce	0. 1	0. 1	0. 1
Department of Transportation	0. 1	0. 1	0. 1
State Department	1. 0	1. 3	1. 4
National Science Foundation	0. 7	1. 0	1. 5
Department of the Interior	9. 1	17. 9	16. 8
1. Bureau of Commercial Fisheries	(3. 3)	(3. 6)	(3. 4)
2. Bureau of Sport Fisheries and Wildlife	(1. 0)	(1. 3)	(1. 5)
3. National Park Service	(0. 3)	(0. 3)	(0. 5)
4. Office of Water Resources Research	(0. 1)	(0. 4)	(0. 5)
5. Federal Water Pollution Control Administration	(4. 4)	(12. 3)	(10. 9)
Department of Defense	3. 8	3. 6	5. 0
1. Department of the Army	(3. 7)	(3. 5)	(4. 9)
2. Department of the Navy	(0. 1)	(0. 1)	(0. 1)
Total	14. 8	24. 0	24. 9

Appendix A-6—Special Analysis: Estuaries

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
Smithsonian Institution	0.1	0.1	0.2
Department of Commerce	0.8	0.8	0.9
Atomic Energy Commission	0.4	0.4	0.4
Department of Transportation	([a])	([a])	([a])
National Science Foundation	1.0	1.5	2.0
Department of the Interior	21.4	22.8	23.4
1. Bureau of Commercial Fisheries	(7.7)	(8.0)	(7.3)
2. Geological Survey	(0.7)	(0.7)	(0.7)
3. Bureau of Sport Fisheries and Wildlife	(6.4)	(6.9)	(7.4)
4. Federal Water Pollution Control Administration	(4.2)	(4.3)	(5.0)
5. Office of Saline Water	(0.6)	(0.8)	(0.7)
6. National Park Service	(1.4)	(1.6)	(1.7)
7. Office of Water Resources Research	(0.4)	(0.5)	(0.6)
Department of Defense	4.5	3.3	4.1
1. Department of the Army	(2.3)	(2.2)	(3.1)
2. Department of the Navy	(2.2)	(1.1)	(1.0)
Total	28.2	28.9	31.0

[a] Less than $50,000

Appendix A-7—Special Analysis: Excess Foreign Currency Programs [a]

[In millions of dollars]

	Estimated FY 1969	Estimated FY 1970	President's budget FY 1971
Fishery development and seafood technology:			
(a) Department of the Interior:			
(1) Fishery resources assessment, development, and management	0	0.1	0
Oceanographic research:			
(a) Department of Commerce (Environmental Science Services Administration)	0.1	0	0.2
(b) Smithsonian Institution:			
(1) Specimen Research	0.8	0.8	0.9
Data Centers:			
(a) Smithsonian Institution:			
(1) Service operations	0.2	0.2	0.3
Total	1.1	1.1	1.4

[a] Unlike the other Special Analyses provided in Appendices A-4, A-5, and A-6, the Excess Foreign Currency totals are not included in the basic marine science analyses by Major Purpose, Agency, and Function (A-1, A-2, and A-3).

APPENDIX B—FEDERAL LEGISLATION AND CONGRESSIONAL RESOLUTIONS RELATED TO MARINE SCIENCES

Appendix B–1—Legislation of the 91st Congress, First Session, Affecting Marine Science Programs

Public Law 91–15 (May 23, 1969)—Amends the Marine Resources and Engineering Development Act of 1966 to authorize continuation of the Marine Sciences Council until June 30, 1970.

Public Law 91–40 (July 8, 1969)—Amends the Merchant Marine Act of 1936 (as amended) to extend vessel construction subsidies until June 30, 1970.

Public Law 91–121 (Nov. 19, 1969)—Authorization for military procurement and research, development, test, and evaluation for fiscal year 1970, including prohibition on expenditures for research not having direct and apparent relationship to specific military function or operation.

Public Law 91–135 (Dec. 5, 1969)—Prevents importation into the United States of species of fish and wildlife determined by Secretary of the Interior to be threatened with worldwide extinction, and prevents interstate shipment of reptiles, amphibians, and other wildlife taken contrary to State law.

Public Law 91–144 (Dec. 11, 1969)—Appropriations for public works, water pollution control, and power development for fiscal year 1970, including $800 million for grants for construction of waste treatment works.

Public Law 91–190 (Jan. 1, 1970)—National Environmental Policy Act of 1969, enunciating policy to create and maintain conditions under which man and nature can exist in productive harmony, specifying need for interagency cooperation, providing for annual Presidential environmental quality report and establishing Council on Environmental Quality in Executive Office of the President.

Appendix B–2—Marine Resources and Engineering Development Act of 1966

(Public Law 89–454, June 17, 1966)

AN ACT To provide for a comprehensive, long-range, and coordinated national program in marine science, to establish a National Council on Marine Resources and Engineering Development, and a Commission on Marine Science, Engineering and Resources, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Marine Resources and Engineering Development Act of 1966".

Sec. 2. (a) It is hereby declared to be the policy of the United States to develop, encourage, and maintain a coordinated, comprehensive, and long-range national program in marine science for the benefit of mankind to assist in protection of health and property, enhancement of commerce, transportation, and national security, rehabilitation of our commercial fisheries, and increased utilization of these and other resources.

(b) The marine science activities of the United States should be conducted so as to contribute to the following objectives:

(1) The accelerated development of the resources of the marine environment.

(2) The expansion of human knowledge of the marine environment.

(3) The encouragement of private investment enterprise in exploration, technological development, marine commerce, and economic utilization of the resources of the marine environment.

(4) The preservation of the role of the United States as a leader in marine science and resource development.

(5) The advancement of education and training in marine science.

(6) The development and improvement of the capabilities, performance, use, and efficiency of vehicles, equipment, and instruments for use in exploration, research, surveys, the recovery of resources, and the transmission of energy in the marine environment.

(7) The effective utilization of the scientific and engineering resources of the Nation, with close cooperation among all interested agencies, public and private, in order to avoid unnecessary duplication of effort, facilities, and equipment, or waste.

(8) The cooperation by the United States with other nations and groups of nations and international organizations in marine science activities when such cooperation is in the national interest.

THE NATIONAL COUNCIL ON MARINE RESOURCES AND ENGINEERING DEVELOPMENT

Sec. 3. (a) There is hereby established, in the Executive Office of the President, the National Council on Marine Resources and Engineering Development (hereinafter called the "Council") which shall be composed of—

(1) The Vice President, who shall be Chairman of the Council.
(2) The Secretary of State.
(3) The Secretary of the Navy.
(4) The Secretary of the Interior.
(5) The Secretary of Commerce.
(6) The Chairman of the Atomic Energy Commission.
(7) The Director of the National Science Foundation.
(8) The Secretary of Health, Education, and Welfare.
(9) The Secretary of the Treasury.

(b) The President may name to the Council such other officers and officials as he deems advisable.

(c) The President shall from time to time designate one of the members

of the Council to preside over meetings of the Council during the absence, disability, or unavailability of the Chairman.

(d) Each member of the Council, except those designated pursuant to subsection (b), may designate any officer of his department or agency appointed with the advice and consent of the Senate to serve on the Council as his alternate in his unavoidable absence.

(e) The Council may employ a staff to be headed by a civilian executive secretary who shall be appointed by the President and shall receive compensation at a rate established by the President at not to exceed that of level II of the Federal Executive Salary Schedule. The executive secretary, subject to the direction of the Council, is authorized to appoint and fix the compensation of such personnel, including not more than seven persons who may be appointed without regard to civil service laws or the Classification Act of 1949 and compensated at not to exceed the highest rate of grade 18 of the General Schedule of the Classification Act of 1949, as amended, as may be necessary to perform such duties as may be prescribed by the President.

(f) The provisions of this Act with respect to the Council shall expire one hundred and twenty days after the submission of the final report of the Commission pursuant to section 5(h).

RESPONSIBILITIES

Sec. 4. (a) In conformity with the provisions of section 2 of this Act, it shall be the duty of the President with the advice and assistance of the Council to—

(1) survey all significant marine science activities, including the policies, plans, programs, and accomplishments of all departments and agencies of the United States engaged in such activities;

(2) develop a comprehensive program of marine science activities, including, but not limited to, exploration, description and prediction of the marine environment, exploitation and conservation of the resources of the marine environment, marine engineering, studies of air-sea interaction, transmission of energy, and communications, to be conducted by departments and agencies of the United States, independently or in cooperation with such non-Federal organizations as States, institutions and industry;

(3) designate and fix responsibility for the conduct of the foregoing marine science activities by departments and agencies of the United States;

(4) insure cooperation and resolve differences arising among departments and agencies of the United States with respect to marine science activities under this Act, including differences as to whether a particular project is a marine science activity;

(5) undertake a comprehensive study, by contract or otherwise, of the legal problems arising out of the management, use, development, recovery, and control of the resources of the marine environment;

(6) establish long-range studies of the potential benefits to the United States economy, security, health, and welfare to be gained from marine resources, engineering, and science, and the costs involved in obtaining such benefits; and

(7) review annually all marine science activities conducted by departments and agencies of the United States in light of the policies, plans, programs, and priorities developed pursuant to this Act.

(b) In the planning and conduct of a coordinated Federal program the President and the Council shall utilize such staff, interagency, and non-Government advisory arrangements as they may find necessary and appropriate and shall consult with departments and agencies concerned with marine science activities and solicit the views of non-Federal organizations and individuals with capabilities in marine scences.

COMMISSION ON MARINE SCIENCE, ENGINEERING, AND RESOURCES

SEC. 5. (a) The President shall establish a Commission on Marine Science, Engineering, and Resources (in this Act referred to as the "Commission"). The Commission shall be composed of fifteen members appointed by the President, including individuals drawn from Federal and State governments, industry, universities, laboratories and other institutions engaged in marine scientific or technological pursuits, but not more than five members shall be from the Federal Government. In addition the Commission shall have four advisory members appointed by the President from among the Members of the Senate and the House of Representatives. Such advisory members shall not participate, except in an advisory capacity, in the formulation of the findings and recommendations of the Commission. The President shall select a Chairman and Vice Chairman from among such 15 members. The Vice Chairman shall act as Chairman in the latter's absence.

(b) The Commission shall make a comprehensive investigation and study of all aspects of marine science in order to recommend an overall plan for an adequate national oceanographic program that will meet the present and future national needs. The Commission shall undertake a review of existing and planned marine science activities of the United States in order to assess their adequacy in meeting the objectives set forth under section 2(b), including but not limited to the following:

(1) Review the known and contemplated needs for natural resources from the marine environment to maintain our expanding national economy.

(2) Review the surveys, applied research programs, and ocean engineering projects required to obtain the needed resources from the marine environment.

(3) Review the existing national research programs to insure realistic and adequate support for basic oceanographic research that will enhance human welfare and scientific knowledge.

(4) Review the existing oceanographic and ocean engineering programs, including education and technical training, to determine which programs are required to advance our national oceanographic competence and stature and which are not adequately supported.

(5) Analyze the findings of the above reviews, including the economic factors involved, and recommend an adequate national marine science program that will meet the present and future national needs without unnecessary duplication of effort.

(6) Recommend a governmental organizational plan with estimated cost.

(c) Members of the Commission appointed from outside the Government shall each receive $100 per diem when engaged in the actual performance of duties of the Commission and reimbursement of travel expenses, including per diem in lieu of subsistence, as authorized in section 5 of the Administrative Expenses Act of 1946, as amended (5 U.S.C. 73b–2), for persons employed intermittently. Members of the Commission appointed from within the Government shall serve without additional compensation to that received for their services to the Government but shall be reimbursed for travel expenses, including per diem in lieu of subsistence, as authorized in the Act of June 9, 1949, as amended (5 U.S.C. 835–842).

(d) The Commission shall appoint and fix the compensation of such personnel as it deems advisable in accordance with the civil service laws and the Classification Act of 1949, as amended. In addition, the Commission may secure temporary and intermittent services to the same extent as is authorized for the departments by section 15 of the Administrative Expenses Act of 1946 (60 Stat. 810) but at rates not to exceed $100 per diem for individuals.

(e) The Chairman of the Commission shall be responsible for (1) the assignment of duties and responsibilities among such personnel and their continuing supervision, and (2) the use and expenditures of funds available to the Commission. In carrying out the provisions of this subsection, the Chairman shall be governed by the general policies of the Commission with respect to the work to be accomplished by it and the timing thereof.

(f) Financial and administrative services (including those related to budgeting, accounting, financial reporting, personnel, and procurement) may be provided the Commission by the General Services Administration, for which payment shall be made in advance, or by reimbursement from funds of the Commission in such amounts as may be agreed upon by the Chairman of the Commission and the Administrator of General Services: *Provided,* That the regulations of the General Services Administration for the collection of indebtedness of personnel resulting from erroneous payments (5 U.S.C. 46d) shall apply to the collection of erroneous payments made to or on behalf of a Commission employee, and regulations of said Administrator for the administrative control of funds (31 U.S.C. 665(g)) shall apply to appropriations of the Commission: *And provided further,* That the Commission shall not be required to prescribe such regulations.

(g) The Commission is authorized to secure directly from any executive department, agency, or independent instrumentality of the Government any information it deems necessary to carry out its functions under this Act; and each such department, agency, and instrumentality is authorized to cooperate with the Commission and, to the extent permitted by law, to furnish such information to the Commission, upon request made by the Chairman.

(h) The Commission shall submit to the President, via the Council, and to the Congress not later than eighteen months after the establishment of the Commission as provided in subsection (a) of this section, a final report of its findings and recommendations. The Commission shall cease to exist thirty days after it has submitted its final report.

INTERNATIONAL COOPERATION

SEC. 6. The Council, under the foreign policy guidance of the President and as he may request, shall coordinate a program of international cooperation in work done pursuant to this Act, pursuant to agreements made by the President with the advice and consent of the Senate.

REPORTS

SEC. 7. (a) The President shall transmit to the Congress in January of each year a report, which shall include (1) a comprehensive description of the activities and the accomplishments of all agencies and departments of the United States in the field of marine science during the preceding fiscal year, and (2) an evaluation of such activities and accomplishments in terms of the objectives set forth pursuant to this Act.

(b) Reports made under this section shall contain such recommendations for legislation as the President may consider necessary or desirable for the attainment of the objectives of this Act, and shall contain an estimate of funding requirements of each agency and department of the United States for marine science activities during the succeeding fiscal year.

DEFINITIONS

SEC. 8. For the purposes of this Act the term "marine science" shall be deemed to apply to oceanographic and scientific endeavors and disciplines, and engineering and technology in and with relation to the marine environment; and the term "marine environment" shall be deemed to include (a) the oceans, (b) the Continental Shelf of the United States, (c) the Great Lakes, (d) seabed and subsoil of the submarine areas adjacent to the coasts of the United States to the depth of two hundred meters, or beyond that limit, to where the depths of the superjacent waters admit of the exploitation of the natural resources of such areas, (e) the seabed and subsoil of similar submarine areas adjacent to the coasts of islands which comprise United States territory, and (f) the resources thereof.

AUTHORIZATION

SEC. 9. There are hereby authorized to be appropriated such sums as may be necessary to carry out this Act, but sums appropriated for any one fiscal year shall not exceed $1,500,000.

AMENDMENT

(Public Law 90–242, January 2, 1968)

AN ACT To amend the Marine Resources and Engineering Development Act of 1966, as amended, to extend the period of time within which the Commission on Marine Science, Engineering, and Resources is to submit its final report and to provide for a fixed expiration date for the National Council on Marine Resources and Engineering Development.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Marine Resources and Engineering Development Act of 1966 is amended as follows:

Subparagraph (h) of section 5 is amended by striking out "eighteen" and inserting "twenty-four" in lieu thereof.

Sec. 2. Subparagraph (f) of section 3 is amended by striking out "one hundred and twenty days after the submission of the final report of the Commission pursuant to section 5(h)." and inserting in lieu thereof " 'on June 30, 1969.' ".

Amendment

(Public Law 91–95, May 23, 1969)

AN ACT To amend the Marine Resources and Engineering Development Act of 1966 to continue the National Council on Marine Resources and Engineering Development, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That subsection (f) of section 3 of the Marine Resources and Engineering Development Act of 1966 (33 U.S.C. 1102(f)) is amended by striking out "June 30, 1969" and inserting in lieu thereof "June 30, 1970".

Sec. 2. Section 9 of such Act (33 U.S.C. 1108) is amended by striking out "$1,500,000" and inserting in lieu thereof "$1,200,000".

Appendix B–3—National Sea Grant College and Program Act of 1966

(Public Law 89–688, October 15, 1966)

AN ACT To amend the Marine Resources and Engineering Development Act of 1966 to authorize the establishment and operation of sea grant colleges and programs by initiating and supporting programs of education and research in the various fields relating to the development of marine resources, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Marine Resources and Engineering Development Act of 1966 is amended by adding at the end thereof the following new title:

"TITLE II—SEA GRANT COLLEGES AND PROGRAMS

"SHORT TITLE

"Sec. 201. This title may be cited as the 'National Sea Grant College and Program Act of 1966.'

"DECLARATION OF PURPOSE

"Sec. 202. The Congress hereby finds and declares—

"(a) that marine resources, including animal and vegetable life and mineral wealth, constitute a far-reaching and largely untapped asset of immense potential significance to the United States; and

"(b) that it is in the national interest of the United States to develop the skilled manpower, including scientists, engineers, and technicians, and the facilities and equipment necessary for the exploitation of these resources; and

"(c) that aquaculture, as with agriculture on land, and the gainful use of marine resources can substantially benefit the United States, and ultimately the people of the world, by providing greater economic opportunites, including expanded employment and commerce; the enjoyment and use of our marine resources; new sources of food; and new means for the development of marine resources; and

"(d) that Federal support toward the establishment, development, and operation of programs by sea grant colleges and Federal support of other sea grant programs designed to achieve the gainful use of marine resources, offer the best means of promoting programs toward the goals set forth in clauses (a), (b), and (c), and should be undertaken by the Federal Government; and

"(e) that in view of the importance of achieving the earliest possible institution of significant national activities related to the development of marine resources, it is the purpose of this title to provide for the establishment of a program of sea grant colleges and education, training, and research in the fields of marine science, engineering, and related disciplines.

"GRANTS AND CONTRACTS FOR SEA GRANT COLLEGES AND PROGRAMS

"Sec. 203. (a) The provisions of this title shall be administered by the National Science Foundation (hereafter in this title referred to as the 'Foundation').

"(b) (1) For the purpose of carrying out this title, there is authorized to be appropriated to the Foundation for the fiscal year ending June 30, 1967, not to exceed the sum of $5,000,000, for the fiscal year ending June 30, 1968, not to exceed the sum of $15,000,000, and for each subsequent fiscal year only such sums as the Congress may hereafter specifically authorize by law.

"(2) Amounts appropriated under this title are authorized to remain available until expended.

"MARINE RESOURCES

"Sec. 204. (a) In carrying out the provisions of this title the Foundation shall (1) consult with those experts engaged in pursuits in the various fields related to the development of marine resources and with all departments and agencies of the Federal Government (including the United States Office of Education in all matters relating to education) interested in, or affected by, activities in any such fields, and (2) seek advice and counsel from the National Council on Marine Resources and Engineering Development as provided by section 205 of this title.

"(b) The Foundation shall exercise its authority under this title by—

"(1) initiating and supporting programs at sea grant colleges and other suitable institutes, laboratories, and public or private agencies for the education of participants in the various fields relating to the development of marine resources;

"(2) initiating and supporting necessary research programs in the various fields relating to the development of marine resources, with preference given to research aimed at practices, techniques, and design of equipment applicable to the development of marine resources; and

"(3) encouraging and developing programs consisting of instruction, practical demonstrations, publications, and otherwise, by sea grant colleges and other suitable institutes, laboratories, and public or private agencies through marine advisory programs with the object of imparting useful information to persons currently employed or interested in the various fields related to the development of marine resources, the scientific community, and the general public.

"(c) Programs to carry out the purposes of this title shall be accomplished through contracts with, or grants to, suitable public or private institutions of higher education, institutes, laboratories, and public or private agencies which are engaged in, or concerned with, activities in the various fields related to the development of marine resources, for the establishment and operation by them of such programs.

"(d) (1) The total amount of payments in any fiscal year under any grant to or contract with any participant in any program to be carried out by such participant under this title shall not exceed 66⅔ per centum of the total cost of such program. For purposes of computing the amount of the total cost of any such program furnished by any participant in any fiscal year, the Foundation shall include in such computation an amount equal to the reasonable value of any buildings, facilities, equipment, supplies, or services provided by such participant with respect to such program (but not the cost or value of land or of Federal contributions).

"(2) No portion of any payment by the Foundation to any participant in any program to be carried out under this title shall be applied to the purchase or rental of any land or the rental, purchase, construction, preservation, or repair of any building, dock, or vessel.

"(3) The total amount of payments in any fiscal year by the Foundation to participants within any State shall not exceed 15 per centum of the total amount appropriated to the Foundation for the purposes of this title for such fiscal year.

"(e) In allocating funds appropriated in any fiscal year for the purposes of this title the Foundation shall endeavor to achieve maximum participation by sea grant colleges and other suitable institutes, laboratories, and public or private agencies throughout the United States, consistent with the purposes of this title.

"(f) In carrying out its functions under this title, the Foundation shall attempt to support programs in such a manner as to supplement and not duplicate or overlap any existing and related Government activities.

"(g) Except as otherwise provided in this title, the Foundation shall, in carrying out its functions under this title, have the same powers and authority it has under the National Science Foundation Act of 1950 to carry out its functions under that Act.

"(h) The head of each department, agency, or instrumentality of the Federal Government is authorized, upon request of the Foundation, to make available to the Foundation, from time to time, on a reimbursable basis, such personnel, services, and facilities as may be necessary to assist the Foundation in carrying out its functions under this title.

"(i) For the purposes of this title—

"(1) the term 'development of marine resources' means scientific

endeavors relating to the marine environment, including, but not limited to, the fields oriented toward the development, conservation, or economic utilization of the physical, chemical, geological, and biological resources of the marine environment; the fields of marine commerce and marine engineering; the fields relating to exploration or research in, the recovery of natural resources from, and the transmission of energy in, the marine environment; the fields of oceanography and oceanology; and the fields with respect to the study of the economic, legal, medical, or sociological problems arising out of the management, use, development, recovery, and control of the natural resources of the marine environment;

"(2) the term 'marine environment' means the oceans; the Continental Shelf of the United States; the Great Lakes; the seabed and subsoil of the submarine areas adjacent to the coasts of the United States to the depth of two hundred meters, or beyond that limit, to where the depths of the superjacent waters admit of the exploitation of the natural resources of the area; the seabed and subsoil of similar submarine areas adjacent to the coasts of islands which comprise United States territory; and the natural resources thereof;

"(3) the term 'sea grant college' means any suitable public or private institution of higher education supported pursuant to the purposes of this title which has major programs devoted to increasing our Nation's utilization of the world's marine resources; and

"(4) the term 'sea grant program' means (A) any activities of education or research related to the development of marine resources supported by the Foundation by contracts with or grants to institutions of higher education either initiating, or developing existing programs in fields related to the purposes of this title, (B) any activities of education or research related to the development of marine resources supported by the Foundation by contracts with or grants to suitable institutes, laboratories, and public or private agencies, and (C) any programs of advisory services oriented towards imparting information in fields related to the development of marine resources supported by the Foundation by contracts with or grants to suitable institutes, laboratories, and public or private agencies.

"ADVISORY FUNCTIONS

"SEC. 205. The National Council on Marine Resources and Engineering Development established by section 3 of title I of this Act shall, as the President may request—

"(1) advise the Foundation with respect to the policies, procedures, and operations of the Foundation in carrying out its functions under this title;

"(2) provide policy guidance to the Foundation with respect to contracts or grants in support of programs conducted pursuant to this title, and make such recommendations thereon to the Foundations as may be appropriate; and

"(3) submit an annual report on its activities and its recommendations under this section to the Speaker of the House of Representatives, the Committee on Merchant Marine and Fisheries of the House of

Representatives, the President of the Senate, and the Committee on Labor and Public Welfare of the Senate."

SEC. 2. (a) The Marine Resources and Engineering Development Act of 1966 is amended by striking out the first section and inserting in lieu thereof the following:

"TITLE I—MARINE RESOURCES AND ENGINEERING DEVELOPMENT

"SHORT TITLE

"SECTION 1. This title may be cited as the 'Marine Resources and Engineering Development Act of 1966'."

(b) Such Act is further amended by striking out "this Act" the first place it appears in section 4(a), and also each place it appears in sections 5(a), 8, and 9, and inserting in lieu thereof in each such place "this title".

AMENDMENT

(PUBLIC LAW 90–477, AUGUST 11, 1968)

AN ACT To amend title II of the Marine Resources and Engineering Development Act of 1966

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That title II of the Marine Resources and Engineering Development Act of 1966 is amended as follows:

(1) Section 203(b)(1) of the Marine Resources and Engineering Development Act of 1966 is amended by inserting immediately after "for the fiscal year ending June 30, 1968, not to exceed the sum of $15,000,000," the following: "for the fiscal year ending June 30, 1969, not to exceed the sum of $6,000,000, for the fiscal year ending June 30, 1970, not to exceed the sum of $15,000,000.".

(2) Section 204(d)(1) of the Marine Resources and Engineering Development Act of 1966 is amended by deleting the phrase "in any fiscal year" each time it appears therein.

Appendix B–4—Concurrent Resolutions Introduced in Congress on International Decade of Ocean Exploration

H. Con. Res. 57 [1]

Whereas the Congress finds that an unprecedented scientific and technological readiness now exists for exploration of the oceans and their resources; and

Whereas accelerated exploration of the nature, extent, and distribution of ocean resources could significantly increase the food, mineral, and energy resources available for the benefit of mankind; and

[1] A similar concurrent resolution (S. Con. Res. 23) was introduced in the Senate. Action has not been taken upon either concurrent resolution as of Jan. 15, 1970.

Whereas improved understanding of ocean processes would enhance the protection of life and property against severe storms and other hazards, would further the safety of maritime commerce, would directly contribute to the development of coastal areas of the Nation, would benefit the Nation's fishing and mineral extractive industries, and would contribute to advancement of a broad range of scientific disciplines; and

Whereas realization of the full potential of the oceans will require a long-term program of exploration, observation, and study on a worldwide basis, utilizing ships, buoys, aircraft, satellites, undersea submersibles, and other platforms, advanced navigation systems, and expanded data processing and distribution facilities; and

Whereas the inherently international character of ocean phenomena has attracted the interest of many nations; and

Whereas excellence, experience, and capabilities in marine science and technology are shared by many nations and a broad program of ocean exploration can most effectively and economically be carried out through a cooperative effort by many nations of the world; and

Whereas the United States has begun to explore, through the United Nations and other forums, international interest in a long-term program of ocean exploration: Now, therefore, be it

Resolved by the House of Representatives (the Senate concurring), That it is the sense of Congress that the United States should participate in and give full support to an International Decade of Ocean Exploration during the 1970's which would include (1) an expanded national program of exploration in waters close to the shores of the United States, (2) intensified exploration activities in waters more distant from the United States, and (3) accelerated development of the capabilities of the United States to explore the oceans and particularly the training and education of needed scientists, engineers, and technicians.

Sec. 2. It is further the sense of Congress that the President should cooperate with other nations in (1) encouraging broad international participation in an International Decade of Ocean Exploration, (2) sharing results and experiences from national ocean exploration programs, (3) planning and coordinating international cooperative projects within the framework of a sustained, long-range international effort to investigate the world's oceans, (4) strengthening and expanding international arrangements for the timely international exchange of oceanographic data, and (5) providing appropriate technical and training assistance and facilities to the developing countries and support to international organizations so they may effectively contribute their share to the International Decade of Ocean Exploration.

Sec. 3. It is further the sense of Congress that the President in his annual report to the Congress on marine science affairs pursuant to Public Law 89–454 should transmit to the Congress a plan setting forth the proposed participation of the United States for the next fiscal year in the International Decade of Ocean Exploration. The plan should contain a statement of the activities to be conducted and specify the department or agency of the Government which would conduct the activity and seek appropriations therefor.

APPENDIX C—MARINE SCIENCES COUNCIL ACTIVITIES, CONTRACTS, AND REPORTS

Appendix C-1—Congressional Testimony on Government-Wide Issues [1]

Date	Topic	Committee
10/10/66	Council program and budget for fiscal year 1967.	*House*—Subcommittee on Supplemental Appropriations.[2]
10/17/66	Council program and budget for fiscal year 1967.	*Senate*—Subcommittee on Deficiencies and Supplementals.[2]
3/13/67	Council program and budget for fiscal year 1968.	*House*—Subcommittee on Interior and Related Agencies.[2]
3/17/67	Council program and budget for fiscal year 1968.	*Senate*—Subcommittee on Interior and Related Agencies.[2]
8/17/67	Review of Council activities on first anniversary of Council.	*House*—Subcommittee on Oceanography.[3]
10/11/67	H.R. 13273, to extend deadline for Commission report and lifetime of the Council.	*House*—Subcommittee on Oceanography.[3]
11/28/67	S. 1262, to authorize Corps of Engineers shoreline study.	*Senate*—Subcommittee on Flood Control, Rivers and Harbors.[4]
2/19/68	H.R. 15224, improvements for Coast Guard, research ship.	*House*—Subcommittee on Coast Guard, C &GS, and Navigation.[3]
3/ 7/68	Council program and budget for fiscal year 1969.	*Senate*—Subcommittee on Interior and Related Agencies.[2]
3/13/68	Council program and budget for fiscal year 1969.	*House*—Subcommittee on Interior and Related Agencies.[2]
4/ 9/68	H.R. 15490, to increase appropriation for FPC pilot plant.	*House*—Subcommittee on Fisheries and Wildlife Conservation.[3]
5/27/68	H.R. 11584, et al., to establish system of marine sanctuaries.	*House*—Subcommittee on Oceanography.[3]
6/24/68	H.R. 13781, to extend authorization of the Sea Grant Program.	*Senate*—Committee on Commerce.
6/26/68	S. 3030, et al., to enable BCF to proceed with FPC plant.	*House*, Subcommittee on Fisheries and Wildlife Conservation.[3]
7/29/68	H. Con. Res. 803, to express concurrence with objectives of Decade of Ocean Exploration.	*House*—Subcommittee on Oceanography.[3]
3/ 7/69	H.R. 5829, to extend lifetime of Council to June 30, 1970.	*House*—Subcommittee on Oceanography.
4/ 1/69	H.R. 6495, to control oil pollution from ships, and other purposes.	*House*—Subcommittee on Oceanography.
7/ 9/69	Council program and budget for fiscal year 1969.	*Senate*—Appropriations, Subcommittee on the Department of the Interior and related agencies.
7/22/69, 7/28/69	Centralization of Federal science activities.	*House*—Science and Astronautics, Subcommittee on Science, Research, and Development.
7/31/69	Use of marine sources of food to improve nutritional conditions of American citizens.	*Senate*—Select Committee on Nutrition and Human Needs.
9/16/69	National oceanographic program and report of Commission on Marine Science, Engineering, and Resources.	*House*—Merchant Marine and Fisheries, Subcommittee on Oceanography.

[1] Testimony by Executive Secretary, Marine Sciences Council.
[2] Committee on Appropriations.
[3] Committee on Merchant Marine and Fisheries.
[4] Committee on Public Works.

APPENDIX C—MARINE SCIENCES COUNCIL ACTIVITIES, CONTRACTS, AND REPORTS—Continued

Appendix C–2—Contracts Sponsored by the Marine Sciences Council

Subject	Contractor	Amount	Report No.[1]
International legal problems of ocean research.	William T. Burke, Ohio State University.	$7, 100	PB 177724
Law for sea's minerals.......	Louis Henkin, Columbia Law School.	$10, 000	PB 177725
Potential of spacecraft oceanography.	General Electric, Valley Forge, Pa.	$59, 433	PB 177726
Potential of aquaculture.....	American Institute of Biological Science, Washington, D.C.	$30, 756	PB 177767 PB 177768
Encouraging marine resource development.[2]	National Planning Association, Washington, D.C.	$30, 000	PB 178203
Systems analysis of specified trawler operations.	Litton Industries, Beverly Hills, Calif.	$89, 373	PB 178661 PB 178662
Nonmilitary needs for underwater technology.	Southwest Research Institute, San Antonio, Tex.	$63, 000	PB 178687
International law and fishery policy.	Paul W. Dodyk, Columbia Law School.	$7, 425	PB 179427
Multiple use of Chesapeake Bay.	Trident Engineering Associates, Annapolis, Md.	$31, 112	PB 179844
Economic potential of U.S. continental margin.	Economic Associates, Inc., Washington, D.C.	$70, 000	PB 180118
Management of marine data systems, Phase I.	System Development Corp., Santa Monica, Calif.	$75, 000	AD 673992 673993
Evaluation of marine resource statistics.	Surveys & Research Corp., Washington, D.C.	$6, 400	
Outline of marine legal conflicts.	William L. Griffin, Washington, D.C.	$4, 200	
International Indian Ocean Expedition.	Robert G. Snider, State College, Pa.	$6, 000	
Legal aspects of coastal land-sea interface.	Albert Garretson, New York University Law School.	$20, 000	PB 179428
Legal aspects of Great Lakes resources.	.....do......................	$20, 000	PB 186000
Seminar on liability aspects of marine activities.	American Trial Lawyers Association, New York, N.Y.	$1, 000	
Multiple use of the Greater Seattle Harbor.	Management & Economics Research, Inc., Palo Alto, Calif.	$35, 235	PB 183026
Conference on future of fishing industry.	University of Washington, Seattle, Wash.	$5, 000	

See footnotes at end of table.

APPENDIX C—MARINE SCIENCES COUNCIL ACTIVITIES, CONTRACTS, AND REPORTS—Continued

Appendix C–2—Continued

Subject	Contractor	Amount	Report No.[1]
Multiple use of Lakes Erie and Superior.	National Planning Association, Washington, D.C.	$41, 194	PB 185163
Multinational investments in marine sciences.	Institute of Politics and Planning, Washington, D.C.	$25, 000	PB 182437
Catalogue of marine research. [3]	Smithsonian Institution, Washington, D.C.	$43, 186	
Science and engineering aspects of Decade of Ocean Exploration.	National Academies of Sciences and Engineering, Washington, D.C.	$50, 000	PB 183679
Gulf of Mexico Research and Environmental Program.	Gulf Universities Research Corp., Houston, Tex.	$10, 000	PB 183680
Economic aspects of selected ocean related activities.	Massachusetts Institute of Technology.	$74, 300	
Collection and analysis of information in support of the gulf environment measurement program.	Florida Institute of Oceanography.	$2, 000	
Federal Planning for U.S. Participation in the International Decade of Ocean Exploration.	National Academies of Sciences and Engineering, Washington, D.C.	$43, 000	
Alternative international seabed regimes governing development of nonliving resources.	The Brookings Institution, Washington, D.C.	$15, 000	
Intergovernmental Relations and the National Interest in the U.S. Coastal Zone.	Harold F. Wise & Associates, Washington, D.C.	$20, 000	PB 184212
Management of Marine Data Systems, Phase II.	System Development Corp., Santa Monica, Calif.	$577, 805	AD 699125 (Vol 1). AD 699126 (Vol 2).

[1] Reports available from the Clearinghouse for Federal Scientific and Technical Information, Springfield Va. 22151.
[2] Jointly sponsored with National Science Foundation.
[3] For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Appendix C-3—Reports of the Marine Sciences Council

Title	Date
Marine Science Affairs—A Year of Transition: The First Report of the President to the Congress on Marine Resources and Engineering Development.	February 1967[1]
Aquatic Sciences in the Great Lakes Area	March 1967 [1]
Oceanographic Ship Operating Schedules, 1968	July 1967 [2]
University Curricula in the Marine Sciences, Academic Year 1967–68.	August 1967 [2]
Addendum to University Curricula in the Marine Sciences, Academic Year 1967–68.	August 1967 [2]
United States Activities in Spacecraft Oceanography	October 1967 [1]
Marine Science Affairs—A Year of Plans and Progress: The Second Report of the President to the Congress on Marine Resources and Engineering Development.	February 1968 [1]
Marine Science Activities of Canada and the Nations of Europe	April 1968 [1]
Marine Science Activities of the Nations of East Asia	April 1968 [1]
Marine Science Activities of the Nations of Latin America	April 1968 [1]
Marine Science Activities of the Nations of the Near East and South Asia.	April 1968 [1]
Marine Science Activities of the Nations of Africa	April 1968 [1]
Oceanographic Ship Operating Schedules, 1968	April 1968 [2]
International Decade of Ocean Exploration	May 1968 [1]
Oceanographic Ship Operating Schedules, September 1968–February 1969.	August 1968 [2]
Marine Science Affairs—A Year of Broadened Participation: The Third Report of the President to the Congress on Marine Resources and Engineering Development	January 1969 [1]
University Curricula in the Marine Sciences and Related Sciences and Related Fields—Academic Years 1969–70 and 1970–71. [1]	October 1969[1]
Marine Research Fiscal Year 1968—A Catalog of Unclassified Marine Research Activities Sponsored During Fiscal Year 1968 by Federal and Nonfederal Organizations. [1]	July 1969[1]
Oceanographic Ship Operating Schedules, November 1969–April 1970.[2]	October 1969[2]

[1] For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

[2] Available from Marine Science Affairs Staff of the Oceanographer of the Navy, Building 159-E, room 476, Navy Yard, Washington, D.C. 20390.

APPENDIX D—ACTIVITIES OF INTERNATIONAL ORGANIZATIONS AND OTHER NATIONS

Appendix D-1—Resolutions Adopted by the United Nations General Assembly

Question of the Reservation Exclusively for Peaceful Purposes of the Sea-Bed and the Ocean Floor, and the Subsoil Thereof, Underlying the High Seas Beyond the Limits of Present National Jurisdiction, and the Use of Their Resources in the Interests of Mankind

A. 2574A (XXIV)

Ascertaining Member Views on Convening Law of the Sea Conference

The General Assembly,

Recalling its resolutions 2340 (XXII) of 18 December 1967 and 2467 (XXIII) of 21 December 1968,

Having regard for the fact that the problems relating to the high seas, territorial waters, contiguous zones, the continental shelf, the superjacent waters, and the sea-bed and ocean floor beyond national jurisdiction, are closely linked together,

Considering that the definition of the Continental Shelf contained in the Convention on the Continental Shelf of 29 April 1958 does not define with sufficient precision the limits of the area over which a coastal State exercises sovereign rights for the purpose of exploration and exploitation of natural resources, and that customary international law on the subject is inconclusive,

Noting that developing technology is making the entire sea-bed and ocean floor progressively accessible and exploitable for scientific, economic, military and other purposes,

Affirming that there exists an area of the sea-bed and ocean floor and the subsoil thereof which lies beyond the limits of national jurisdiction,

Affirming further that this area should be used exclusively for peaceful purposes and its resources utilized for the benefit of all mankind,

Convinced of the urgent necessity of preserving this area from encroachment, or appropriation by any State, inconsistent with the common interest of mankind,

Noting that the establishment of an equitable international régime for this area would facilitate the task of determining the limits of the area to which that régime is to apply,

Noting further the continuing efforts of the Committee on the Peaceful Uses of the Sea-Bed and the Ocean Floor beyond the Limits of National

Jurisdiction to elaborate such a régime in accordance with paragraph 2(*a*) of resolution 2467A (XXIII),

1. *Requests* the Secretary-General to ascertain the views of Member States on the desirability of convening at an early date a conference on the law of the sea to review the régimes of the high seas, the continental shelf, the territorial sea and contiguous zone, fishing and conservation of the living resources of the high seas, particularly in order to arrive at a clear, precise and internationally accepted definition of the area of the sea-bed and ocean floor which lies beyond national jurisdiction, in the light of the international régime to be established for that area;

2. *Requests* the Secretary-General to report on the results of his consultation to the General Assembly at its twenty-fifth session.

15 December 1969

B. 2574B (XXIV)

Requesting U.N. Sea-Bed Committee to Prepare Sea-Bed Principles and Rules for Exploitation of Sea-Bed Resources.

The General Assembly,

Recalling its resolution 2340 (XXII) of 18 December 1967 and 2467 (XXIII) of 21 December 1968,

Having considered the report of the Committee on the Peaceful Uses of the Sea-Bed and the Ocean Floor beyond the Limits of National Jurisdiction,

Expressing its satisfaction to the International Atomic Energy Agency, the International Labour Organisation, the Food and Agriculture Organization of the United Nations, the United Nations Educational, Scientific and Cultural Organization, and to the Intergovernmental Oceanographic Commission and the Inter-Governmental Maritime Consultative Organization for their participation in and contribution to the Committee's work, as well as to the Secretary-General for his assistance,

1. *Takes note* with appreciation of the report of the Committee on the Peaceful Uses of the Sea-Bed and the Ocean Floor beyond the Limits of National Jurisdiction;

2. *Invites* the Committee to consider further the questions entrusted to it under resolution 2467 (XXIII) with a view to formulating recommendations on these questions, in the light of the reports and studies to be made available to it and taking into account the views expressed in the General Assembly at its twenty-fourth session;

3. *Notes with interest* the synthesis at the end of the report of the Legal Sub-Committee which reflects the extent of the work done in the formulation of principles designed to promote international co-operation in the exploration and use of the sea-bed and the ocean floor, and the subsoil thereof, beyond the limits of national jurisdiction and to ensure the exploitation of their resources for the benefit of mankind, irrespective of the geographical location of States, taking into account the special interests and needs of the developing countries, whether land-locked or coastal;

4. *Requests* the Committee to expedite its work of preparing a comprehensive and balanced statement of these principles and to submit a draft declaration to the General Assembly at its twenty-fifth session;

5. *Takes note* of the suggestions contained in the report of the Economic and Technical Sub-Committee;

6. *Requests* the Committee to formulate recommendations regarding the economic and technical conditions and the rules for the exploitation of the resources of this area in the context of the régime to be set up.

15 December 1969

C. 2574C (XXIV)

Requesting a Further Study on International Machinery

The General Assembly,

Recalling its resolution 2467 (XXIII) of 21 December 1968,

Noting with appreciation the report of the Committee on the Peaceful uses of the Sea-Bed and the Ocean Floor beyond the Limits of National Jurisdiction,

Noting with satisfaction the study on international machinery prepared by the Secretary-General, which appears as annex II to that report,

Bearing in mind the recommendation of the Committee that the Secretary-General should be requested to continue this study in depth,

1. *Requests* the Secretary-General to prepare a further study on various types of international machinery, particularly a study covering in depth the status, structure, functions and powers of an international machinery, having jurisdiction over the peaceful uses of the sea-bed and the ocean floor, and the subsoil thereof, beyond the limits of national jurisdiction, including the power to regulate, co-ordinate, supervise and control all activities relating to the exploration and exploitation of their resources for the benefit of mankind as a whole, irrespective of the geographical location of States, taking into account the special interests and needs of the developing countries, whether land-locked or coastal;

2. *Requests* the Secretary-General to submit his report thereon to the Committee on the Peaceful Uses of the Sea-Bed and the Ocean Floor beyond the Limits of National Jurisdiction for consideration during one of its sessions in 1970;

3. *Calls upon* the Committee to submit a report on this question to the General Assembly at its twenty-fifth session.

15 December 1969

D. 2574D (XXIV)

Calling for Moratorium on Exploitation of Seabed Resources Pending Establishment of an International Regime

The General Assembly,

Recalling its resolution 2467A (XXIII) of 21 December 1968 to the effect that the exploitation of the sea-bed and the ocean floor, and the subsoil thereof, beyond the limits of national jurisdiction, should be carried out for the benefit of mankind as a whole, irrespective of the geographical location of States, taking into account the special interests and needs of the developing countries,

Convinced that it is essential, for the achievement of this purpose, that

such activities be carried out under an international régime, including appropriate international machinery,

Noting that this matter is under consideration by the Committee on the Peaceful Uses of the Sea-Bed and the Ocean Floor beyond the Limits of National Jurisdiction,

Recalling its resolution 2340 (XXII) of 18 December 1967 on the importance of preserving the sea-bed and the ocean floor, and the subsoil thereof, beyond the limits of national jurisdiction, from action and uses which might be detrimental to the common interests of mankind,

Declares that, pending the establishment of the aforementioned international régime:

(*a*) States and persons, physical or juridical, are bound to refrain from all activities of exploitation of the resources of the area of the sea-bed and ocean floor, and the subsoil thereof, beyond the limits of national jurisdiction;

(*b*) No claim to any part of that area or its resources shall be recognized.

15 December 1969

E. 2560 (XXIV)

Requesting Intergovernment Oceanographic Commission of UNESCO to Implement the Long Term and Expanded Program of Oceanic Exploration and Research and International Decade of Ocean Exploration

The General Assembly,

Recalling the considerations set forth in its resolution 2172 (XXI) of 6 December 1966,

Having noted with appreciation the report of the Secretary-General entitled "Marine science and technology: survey and proposals", submitted in response to resolution 2171 (XXI),

Noting also the note by the Secretary-General on the establishment of an intersecretariat committee, which arose out of the suggestion of the Secretary-General in his report on marine science and technology,

Recognizing the growing awareness of the importance of the oceans to the progress of mankind,

Aware of the need to obtain more information concerning the oceans and their resources,

Recalling the request in its resolution 2414 (XXIII) of 17 December 1968 that the Secretary-General present a comprehensive outline of the scope of a long-term and expanded programme of oceanic exploration and research, of which the international decade of ocean exploration will be an important element, taking into account the recommendations of the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization and in co-operation with other interested intergovernmental organizations,

Recalling also the request in its resolution 2467D (XXIII) of 21 December 1968 that the Intergovernmental Oceanographic Commission intensify its activities in the scientific field, co-operate with the Secretary-General in the preparation of the comprehensive outline, and report to the General Assembly at its twenty-fourth session on progress made in the implementation of that resolution,

Noting Economic and Social Council resolution 1470 (XLVII) of 17 November 1969, which transmits the comprehensive outline to the General Assembly,

1. *Notes with appreciation* the comprehensive outline of the scope of a long-term and expanded programme of oceanic exploration and research, of which the international decade of ocean exploration will be an important element, forwarded by the Chairman of the Intergovernmental Oceanographic Commission to the Secretary-General and enclosed as an annex to a note by the Secretary-General on this subject;

2. *Reaffirms* its conviction that any exploration or research carried out under the long-term and expanded programme will be exclusively scientific in nature and that all such activities falling under the national jurisdiction of a State shall be subject to the previous consent of such State, in accordance with international law;

3. *Requests* the United Nations Educational, Scientific and Cultural Organization and its Intergovernmental Oceanographic Commission to keep that programme up to date and consider its implementation in appropriate stages, in co-operation with other interested organizations, in particular the United Nations, the Food and Agriculture Organization of the United Nations, the World Meteorological Organization and the Inter-Governmental Maritime Consultative Organization;

4. *Urges* Member States to co-operate with the Intergovernmental Oceanographic Commission in the implementation of that programme in appropriate stages;

5. *Commends* the close working relations that have developed between the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization and the United Nations, the Food and Agriculture Organization of the United Nations, the World Meteorological Organization and the Inter-Governmental Maritime Consultative Organization, including the establishment of the Intersecretariat Committee on Scientific Programmes relating to Oceanography, which consists of representatives of the latter organizations, to further, in consultation with the Chairman of the Intergovernmental Oceanographic Commission, the common aspects of the work of the Intergovernmental Oceanographic Commission and those organizations;

6. *Requests* the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization and the organizations mentioned in paragraph 5 to continue to work closely together for the furtherance of their common objectives, within their own terms of reference;

7. *Requests* the Secretary-General to report to the Economic and Social Council on the progress made in the updating and implementation of that programme.

13 December 1969

F. 2566 (XXIV)

Promoting effective measures for the prevention and control of marine pollution

The General Assembly,

Recalling its resolution 2414 (XXIII) of 17 December 1968 requesting

the Secretary-General to report to the General Assembly at its twenty-fifth session, *inter alia,* on the progress achieved by Member States and organizations concerned to promote the adoption of effective international agreements on the prevention and control of marine pollution as may be necessary,

Recalling also its resolution 2467 B (XXIII) of 21 December 1968 on the prevention of marine pollution which might result from exploration and exploitation of the sea-bed and ocean floor,

Noting that a joint group of experts on the scientific aspects of marine pollution has been established by the Food and Agriculture Organization of the United Nations, the United Nations Educational, Scientific and Cultural Organization, the World Meteorological Organization and the Inter-Governmental Maritime Consultative Organization to give advice to these agencies on this subject,

Taking into account the "Comprehensive outline of the scope of the long-term and expanded programme of oceanic exploration and research", providing for a series of scientific studies which would review the state of the ocean and its resources as regards pollution, and forecast long-term trends to assist Governments individually and collectively to take the steps required to counteract its effects,

Bearing in mind arrangements made by the Food and Agriculture Organization of the United Nations for the holding of a technical conference on marine pollution and its effects on living resources and fishing, to be held at Rome, in December 1970,

Recalling its resolution 2398 (XXIII) of 3 December 1968 on the convening in 1972 of a United Nations Conference on the Human Environment and of the Secretary-General on problems of the human environment which *inter alia,* stresses the problems relating to marine pollution,

Noting the resolution on marine pollution adopted by the sixth Assembly of the Inter-Governmental Maritime Consultative Organization calling for an international conference in 1973 for the purpose of preparing a suitable international agreement for placing restraints on the contamination of the sea, land and air by ships and other vessels or equipment operating in the marine environment,

Considering that in spite of the sustained efforts being made at present many aspects of marine pollution have not yet been dealt with or are not being fully covered, and that additional agreements on this subject may be required,

1. *Requests* the Secretary-General, in co-operation with the specialized agencies and intergovernmental organizations concerned, to complement reports and studies under preparation, with special reference to the forthcoming United Nations Conference on the Human Environment, by:

(*a*) A review of harmful chemical substances, radio-active materials and other noxious agents and waste which may dangerously affect man's health and his economic and cultural activities in the marine environment and coastal areas;

(*b*) A review of national activities and activities of specialized agencies of the United Nations and intergovernmental organizations dealing with prevention and control of marine pollution including suggestions for more comprehensive action and improved co-ordination in this field;

(*c*) Seeking the views of Member States on the desirability and feasibility of an international treaty or treaties on the subject;

2. *Requests* the Secretary-General to report to the Economic and Social Council and the Preparatory Committee for the United Nations Conference on the Human Environment, as appropriate. in the framework of the preparations for the Conference.

13 December 1969

G. 2580 (XXIV)

Co-ordination of maritime activities

The General Assembly,

Having considered the report of the Enlarged Committee for Programme and Co-ordination,

Noting that the Enlarged Committee was unable in the time available to give thorough consideration to a proposal for more systematic co-ordination of continuing activities of the United Nations system relating to the seas and oceans, is,

Aware of the complexity of the co-ordination of existing international activities with regard to marine science and its applications and that the field of marine science is only one aspect of the existing activities of the United Nations system relating to the seas and oceans,

Noting that use by States of the marine environment is rapidly becoming intensified and diversified,

Noting with appreciation the work done in this field by the organizations in the United Nations system.

Concerned that present international machinery may not permit a prompt, effective and flexible response to existing and emerging needs of States members of the United Nations,

Recognizing that, in order to avoid the overlapping and duplication of programmes and gaps in competence, a full review of the existing activities of United Nations system of organizations relating to the seas and oceans may be urgently required,

1. *Requests* the Economic and Social Council, at its organizational session in January 1970, to consider instructing the Committee for Programme and Co-ordination, after reconstitution, to examine the need for a comprehensive review of existing activities of the United Nations system relating to the seas and oceans in the light of present and emerging needs of Member States, with a view to making the Committee's recommendations available to the Council at is forty-ninth session;

2. *Requests* the Secretary-General to assist the Committee for Programme and Co-ordination in the fulfillment of this task;

3. *Invites* the specialized agencies and the intergovernmental bodies concerned to extend their full co-operation and assistance to the Committee for Programme and Co-ordination.

15 December 1969

Appendix D–2—Seabed Arms Control Treaty

A. 2602F (XXIV)

Resolution Referring Seabed Arms Control Draft Treaty to the Conference of the Committee on Disarmament

"*The General Assembly,*

"*Recognizing* the common interest of mankind in the reservation of the sea-bed and ocean floor exclusively for peaceful purposes,

"*Having considered* the report of the Conference of the Committee on Disarmament of 31 October 1969 and noting with appreciation the work of that Committee in the elaboration of a draft treaty on the prohibition of the emplacement of nuclear weapons and other weapons of mass destruction on the sea-bed and the ocean floor and the subsoil thereof,

"*Noting* the suggestions and proposals in relation to the draft Treaty contained in annex A of the report of the Conference of the Committee on Disarmament, which were made during the course of discussion in the First Committee on this matter, as well as the suggestions made during the special session of the Committee on the Peaceful Uses of the Sea-Bed and the Ocean Floor beyond the Limits of National Jurisdiction,

"*Considering* that the prevention of a nuclear arms race on the sea-bed and ocean floor serves the interests of maintaining world peace, reducing international tensions, and strengthening friendly relations among States,

"*Convinced* that the conclusion of a treaty on the prohibition of the emplacement of nuclear weapons and other weapons of mass destruction on the sea-bed and ocean floor and in the subsoil thereof will constitute a step towards the exclusion of the sea-bed, the ocean floor and the subsoil thereof from the arms race,

"1. *Welcomes* the submission to this Assembly of the Draft Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Sea-Bed and the Ocean Floor and the Subsoil Thereof, contained in annex A of the report of the Conference of the Committee on Disarmament and the various proposals and suggestions made in regard to the draft treaty,

"2. *Calls upon* the Conference of the Committee on Disarmament to take into account all proposals and suggestions that have been made at this session of the General Assembly and to continue its work on this subject so that the text of a draft treaty can be submitted to the General Assembly for its consideration."

16 December 1969

B. *Draft Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Seabed and the Ocean Floor and in the Subsoil thereof Submitted by the Union of Soviet Socialist Republics and United States of America*

The States Parties to this Treaty,

Recognizing the common interest of mankind in the progress of the exploration and use of the seabed and the ocean floor for peaceful purposes,

Considering that the prevention of a nuclear arms race on the seabed and the ocean floor serves the interests of maintaining world peace, reduces international tensions, and strengthens friendly relations among States,

Convinced that this Treaty constitutes a step towards the exclusion of the seabed, the ocean floor and the subsoil thereof from the arms race, and determined to continue negotiations concerning further measures leading to this end,

Convinced that this Treaty constitutes a step towards a Treaty on General and Complete Disarmament under strict and effective international control, and determined to continue negotiations to this end,

Convinced that this Treaty will further the purposes and principles of the Charter of the United Nations, in a manner consistent with the principles of international law and without infringing the freedoms of the high seas,

Have agreed as follows:

Article I

1. The States Parties to this Treaty undertake not to emplant or emplace on the seabed and the ocean floor and in the subsoil thereof beyond the maximum contiguous zone provided for in the 1958 Geneva Convention on the Territorial Sea and the Contiguous Zone any objects with nuclear weapons or any other types of weapons of mass destruction, as well as structures, launching installations or any other facilities specifically designed for storing, testing, or using such weapons.

2. The States Parties to this Treaty undertake not to assist, encourage or induce any State to commit actions prohibited by this Treaty and not to participate in any other way in such actions.

Article II

1. For the purpose of this Treaty the outer limit of the contiguous zone referred to in Article I shall be measured in accordance with the provisions of Section II of the 1958 Geneva Convention on the Territorial Sea and the Contiguous Zone and in accordance with international law.

2. Nothing in this Treaty shall be interpreted as supporting or prejudicing the position of any State Party with respect to rights or claims which such State Party may assert, or with respect to recognition or nonrecognition of rights or claims asserted by any other State, related to waters off its coasts, or to the seabed and the ocean floor.

Article III

1. In order to promote the objectives and ensure the observance of the provisions of this Treaty, the States Parties to the Treaty shall have the right to verify the activities of other States Parties to the Treaty on the seabed and the ocean floor and in the subsoil thereof beyond the maximum contiguous zone, referred to in Article II, if these activities raise doubts concerning the fulfillment of the obligations assumed under this Treaty, without interfering with such activities or otherwise infringing rights recognized under international law, including the freedoms of the high seas.

2. The right of verification recognized by the States Parties in paragraph 1 of this Article may be exercised by any State Party using its own means or with the assistance of any other State Party.

3. The States Parties to the Treaty undertake to consult and to cooperate with a view to removing doubts concerning the fulfillment of the obligations assumed under this Treaty.

Article IV

Any State Party to the Treaty may propose amendments to this Treaty. Amendments must be approved by a majority of the votes of all the States Parties to the Treaty, including those of all the States Parties to this Treaty possessing nuclear weapons, and shall enter into force for each State Party to the Treaty accepting such amendments upon their acceptance by a majority of the States Parties to the Treaty, including the States which possess nuclear weapons and are Parties to this Treaty. Thereafter, the amendments shall enter into force for any other Party to the Treaty after it has accepted such amendments.

Article V

Each party to this Treaty shall in exercising its national sovereignty have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized the supreme interests of its country. It shall give notice of such withdrawal to all other Parties to the Treaty and to the United Nations Security Council three months in advance. Such notice shall include a statement of the extraordinary events it considers to have jeopardized its supreme interests.

Article VI

1. This Treaty shall be open for signature to all States. Any State which does not sign the Treaty before its entry into force in accordance with paragraph 3 of this Article may accede to it at any time.

2. This Treaty shall be subject to ratification by signatory States. Instruments of ratification and of accession shall be deposited with the Governments of ____________, which are hereby designated the Depositary Governments.

3. This Treaty shall enter into force after the deposit of instruments of ratification by twenty-two Governments, including the Governments designated as Depositary Governments of this Treaty.

4. For States whose instruments of ratification or accession are deposited after the entry into force of this Treaty it shall enter into force on the date of the deposit of their instruments of ratification or accession.

5. The Depositary Governments shall forthwide notify the Governments of all States signatory and acceding to this Treaty of the date of each signature, of the date of deposit of each instrument of ratification or of accession, of the date of the entry into force of this Treaty, and of the receipt of other notices.

6. This Treaty shall be registered by the Depositary Governments pursuant to Article 102 of the Charter of the United Nations.

Article VII

This Treaty, the English, Russian, French, Spanish and Chinese texts of which are equally authentic, shall be deposited in the archives of the Depositary Governments. Duly certified copies of this Treaty shall be transmitted by the Depositary Governments to the Governments of the States signatory and acceding thereto.

In witness whereof the undersigned, being duly authorized thereto, have signed this Treaty.

Done in ------------ at ------------ this ------------ day of ------------

APPENDIX E—NATIONAL SEA GRANT PROGRAM ACTIVITIES

In Progress as of Sept. 1, 1969

Summary by Project and Institutional support

	Total activities	Project support	Institutiona support
Education and training	**44**	**21**	**23**
Ocean engineering			
Graduate level	13	6	7
Undergraduate level	3	3	0
Marine sciences			
Graduate level	10	3	7
Undergraduate level	1	0	1
Technician training	11	7	4
Social science, law, and other educational activities	6	2	4
Research	**106**	**35**	**71**
Living resources			
Aquaculture	18	10	8
Fisheries	10	3	7
Drugs and extracts from the sea	5	3	2
Seafood science and technology			
New product and process development	5	1	4
Seafood sanitation and preservation	5	....	5
Management and preservation of the marine environment			
Pollution	7	2	5
Nutrients	5	0	5
Ecology and marine resource development	8	5	3
Environmental science	5	2	3
Mineral resources	4	1	3
Ocean engineering	11	3	8
Marine socio-economics	12	3	9
Marine resource law	6	2	4
Miscellaneous	5	0	5
Advisory services	**10**	**1**	**9**
Total	160	57	103

Institution	Title and principal
	EDUCATION AND TRAINING
	OCEAN ENGINEERING
GRADUATE LEVEL	
University of Washington	New course: Technological problems in gear and vesse development (G. Ivor Jones).
Catholic University of America (*P*).	Development of graduate program in ocean engineering (Frank A. Andrews).
National Academy of Engineering (Department of Navy) (*P*).	Support of Committee on Ocean Engineering of the National Academy of Sciences (Aubrey W. Pryce).
Oregon State University	Ocean engineering curriculum development (Fred J. Burgess).
Texas A&M University	Expansion of coastal engineering curriculum (John B Herbich).
University of Miami	Ocean engineering curriculum development (John C. Steinberg).
University of Michigan	Ocean engineering curriculum development (Ray Yagle).
Scripps Institution of Oceanography (*P*).	Applied ocean sciences curriculum (Hugh Bradner).
University of Wisconsin	Special projects seminar in ocean engineering (Norman E. Huston).
Massachusetts Institute of Technology (*P*).	Development of graduate ocean engineering (Alfred H. Keil).
Stevens Institute of Technology (*P*).	New courses in hydrodynamics and ocean engineering (J. P. Breslin).
University of Hawaii	Graduate laboratory course and basic facilities for education and research in ocean engineering (C. L. Bretschneider).
New York University (*P*)	Development of graduate ocean engineering program (John R. Ragazzini).
UNDERGRADUATE (UPPER DIVISION)	
Florida Atlantic University (*P*).	Development of cooperative undergraduate ocean engineering program (Charles Stephan).
Mississippi State University (*P*).	Gulf Coast Technical Institute—Development of marine technology program (J. E. Thomas).
University of New Hampshire (*P*).	Ocean engineering work experience program (Donald W. Melvin).
	MARINE SCIENCES
GRADUATE LEVEL	
University of Washington	Aquatic stock management course (Ole A. Mathisen, Donald E. Bevan).
Oregon State University	Curriculum development: Marine minerals (LaVerne D. Kulm), seafood technology (David L. Crawford), marine fisheries (Wm. J. McNeil, Wm. G. Pearcy), marine economics (Emery N. Castle), fish pathology (Ivan Pratt), oceanography (John V. Byrne).
Texas A&M University	New courses in seafood technology (Bryant F. Cobb), new courses in marine biology (Sammy M. Ray).

Institution	Title and principal
	EDUCATION AND TRAINING—Continued
	Marine Sciences—Continued
GRADUATE LEVEL—Continued	
University of Miami	Curriculum improvement: marine biology (John S. Bunt), physical and chemical oceanography (Walter Drost-Hansen), marine geology (Cesare Emiliani).
University of Michigan	Resources systems ecology.
Scripps Institution of Oceanography (*P*).	Curricula in marine biology and biological oceanography (John S. Isaacs, E. L. Winterer).
Louisiana State University (*P*).	Marine science curriculum (J. R. Van Lopik).
University of California, Santa Barbara (*P*).	New courses: Cultural geography of the sea and resource ecology of the marine environment (Beryl Golomb, Norman Sanders).
University of Wisconsin	Hydrobiology (John J. Magnuson), Recent advances in limnology and oceanography (A. M. Beeton and Clifford Mortimer), studies of marine fisheries (C. R. Nordon), problems in oceanography (Robert Ragotzkie), new faculty and teaching aids, guest lecture series in oceanography, "berth of opportunity" program, visiting professorship in marine sciences.
University of Hawaii	Marine biology and oceanography curriculum development (G. Murphy, V. E. Brock).
UNDERGRADUATE	
University of Washington	Orientation course in oceanography (Dixy Lee Ray), evaluation and improvement of marine science education (Alyn C. Duxbury).
	Technician Training [1]
University of Washington	Shoreline Community College—Oceanography and marine biology (John C. Serwold); Peninsula College—marine biology, fisheries and hatchery operations (Robert Mausolf), Highline College—Divers (D. Duane Chapman), Clover Park College—Commercial fisheries (Gordon L. Quick).
Oregon State University	Clatsop Community College—Marine technology and deck hands (Capt. J. S. Elsbree).
Texas A&M University	Galveston Community College—Fisheries, deck, oceanographic instrumentation (Henry A. Rowe), James Connally Technical Institute—Oceanographic instrumentation (Roy W. Dugger).
College of Marin (*P*)	Marine technology—Emphasis on physical sciences and electronics (Gordon L. Chan).
University of Miami	Miami-Dade Junior College—Engineering, survey and electronics technology (Richard Benson).
Santa Barbara City College (*P*).	Marine technician program—Oceanographic aids and divers (Robert J. Profant, H. Ransey Parks).
Cape Fear Technical Institute (*P*).	Options in all major technician fields (Arthur W. Jordan).
Southern Maine Vocational Technical Institute (*P*).	Options in all major technician fields (Tapan Banerjee).

See footnote at end of table.

Institution	Title and principal
EDUCATION AND TRAINING—Continued	
Technician Training[1]—Continued	
Del Mar College (*P*)	Planning and initiation of marine electronics technician program (jointly with Southwest Research Institute) (Ted Boaz).
Smithsonian Institution (*P*).	Biological and geological specimen handling and sorting (H. Adair Fehlmann, I. Wallen).
Washington Technical Institute (*P*).	Planning for marine science technology program (Cleveland Dennard).
Social Science, Law, and Other Educational Activities	
Texas A&M University	Development of new marine courses and interdisciplinary degree programs (John Calhoun, Jr.).
Dade County Board of Public Instruction (*P*).	Summer program to place inner city high school youths in oceanographic laboratories (Harriet Ehrhard).
University of Miami	Ocean law (Dennis O'Connor).
University of Rhode Island	Marine affairs graduate program (Lewis Alexander).
Louisiana State University (*P*).	Interdisciplinary seminar in ocean law (Gary Knight).
University of Washington	Fish processing technology (Ivor Jones), marine food processing methods (Ivor Jones, John Liston, and George Pigott).
RESEARCH	
Living Resources	
AQUACULTURE	
University of Washington	Management and improvement of oysters, clams, rainbow trout, and sea-run cutthroat trout (Frieda B. Taub, Kenneth Chew, Lynwood Smith, Ernest O. Salo, James Sadd Lee).
Oregon State University	Culture in artificial environments; culture in improved natural environments; selective breeding of salmon and bivalves (William J. McNeil).
University of Rhode Island	Fisheries under controlled conditions (B. Diamantis, A. Sastry), fisheries population dynamics of lobster, butterfish, and striped bass (H. Lampe).
Texas A&M University	Studies on the pathogenic parasites of commercial molluscs (J. G. Mackin), cell cultures, viruses, and, pathogenic bacteria of marine species (L. C. Grumbles, A. I. Flowers), aquaculture of white and brown shrimp, blue crab, striped mullet, pompano (Kirk Strawn), application of bioengineering: growth characteristics of marine microorganisms (Daniel T. Hansen).
Humboldt State College (*P*).	Sewage fertilization of fish ponds for rearing salmon and trout (George H. Allen), utilization of fish wastes in rearing crabs and fishes in salt and brackish water (John W. DeWitt).
University of Miami	Aquaculture of pink shrimp and spiny lobster (Durbin C. Tabb).

See footnote at end of table.

Institution	Title and principal
	RESEARCH—Continued
	LIVING RESOURCES—Continued
AQUACULTURE—Continued	
Louisiana State University (*P*).	Feasibility of growing pompano and redfish under controlled conditions (J. W. Avault), biodegradation activities and nutritional aspects of marine yeasts (S. P. Meyers).
University of California, Santa Barbara (*P*).	Laboratory rearing and maintenance studies on the behavior of larvae, young, and adults of California spiny lobster *Panulirus interruptus* (James F. Case, James J. Childress), Seaweed resources management (cultivation) (Michael Neushul, Alex C. Charters).
California Institute of Technology (*P*).	Kelp resources development (Wheeler J. North).
University of Miami (*P*)...	Pink shrimp and pompano culture in ponds (C. P. Idyll).
University of New Hampshire (*P*).	Irish moss (red alga) resource development (Arthur C. Mathieson).
Nicholls State College (*P*)..	Brown and white shrimp culture in impoundments (Alva Harris, Curt Rose).
San Diego State College (*P*).	Population biology of spiny lobsters (David Farris).
Virginia Institute of Marine Science (*P*).	Larval rearing, food, and disease (John DuPuy).
University of Delaware (*P*).	Development of shellfish culture techniques (Donald Maurer), selective oyster breeding experiments (Theodore Ritchie), engineering of an environmental control system for cultivating oysters (Oscar R. Harmon).
University of Hawaii.......	Spawning and rearing of selected marine fishes and molluscs (Philip Helfrich).
University of Washington...	Maintenance of algal culture collections (Joyce Lewin, Richard Norris).
University of Michigan.....	Production and trace element composition of benthic algae (C. E. Schelske), Great Lakes benthic algae communities (Eugene F. Stoermer).
FISHERIES	
University of Washington...	Total utilization concept for fish catches (G. M. Pigott, J. Liston), strategy (techniques) of salmon fisheries regulation (Robert L. Burgner).
Oregon State University....	Early life of boreal food fish and shellfish (William Pearcy, William McNeil), benthic fisheries environment off Oregon (Andrew G. Carey), pelagic fisheries environment off Oregon (William G. Pearcy), reproductive cycles of soft shell clams and cockles (Jefferson Gonor), population and community maintenance (Joel Hedgpeth), symbiosis and parasitism of molluscs and fish (Ivan Pratt).
Humboldt State College (*P*).	Seasonal changes in biochemical composition of dungeness crab (William V. Allen), ecology of the gaper clam in northern California (John D. DeMartini).

Institution	Title and principal
	RESEARCH—Continued
	LIVING RESOURCES—Continued
FISHERIES—Continued	
University of Miami	Commercial fisheries projects (acoustic behavior of fish; thread herring study; spiny lobster behavior; shark behavior) (Martin Roessler).
University of Michigan	Biological productivity of Great Lakes.
Louisiana State University *(P)*.	Ecology of brackish water clam *Rangia cuneata* for possible commercial use (H. D. Hoese).
University of Wisconsin	Role of *Cyclops bicuspidatus* in the trophic ecology of Lake Michigan (Alfred M. Beeton), migration and orientation of fish (Arthur D. Hasler), effects of coho salmon on food habits; vertical distribution of yellow perch and cisco (John J. Magnuson).
University of Hawaii	Precious coral fishery; mesobenthic and crustacean resources; reduction of bait fish mortality; fishing gear development (G. I. Murphy, V. E. Brock, W. Baldin).
Virginia Institute of Marine Science *(P)*.	Improvement of estuarine fisheries, management of hard clams, soft crab, bay scallop, finfish stock improvement (Willard Van Engel).
University of Rhode Island	Gear research for pelagic fisheries (trawls, etc.) (S. Saila).
DRUGS AND EXTRACTS FROM THE SEA	
University of Rhode Island	Pharmacognosy (useful extracts of algae) (H. Youngken, L. Worthen), pharmacology (evaluation of toxic responses and testing of extracts) (J. de Feo, D. deFanti).
University of Miami	Enzymes and pharmaceuticals (W. J. Whelan, W. B. Diechmann).
New England Institute *(P)*.	Biomedical materials derived from the sea (host response depressant) (James H. Green).
Lamont-Doherty Geological Observatory *(P)*.	Drugs from the sea (antibiotics, anticancer agents) Guardial M. Sharma).
Clemson University *(P)*	Investigation of the effects of seaweed on plant growth (T. L. Senn).
	SEAFOOD SCIENCE AND TECHNOLOGY
NEW PRODUCT AND PROCESS DEVELOPMENT	
Oregon State University	New species and product development (David L. Crawford), utilization of fish wastes and nutrition studies (David L. Crawford), new equipment and process development (David L. Crawford).
University of Rhode Island	Utilization of industrial fish products by poultry (L. E. Ousterhout), process development for industrial products (T. L. Meade).
University of Wisconsin	Fermentation of fish (T. Richardson, C. H. Amundson), fish extracts for industrial and human use (T. Richardson, C. H. Amundson).

Institution	Title and principal
	RESEARCH—Continued
	Seafood Science and Technology—Continued
NEW PRODUCT AND PROCESS DEVELOPMENT—Continued	
Lamont-Doherty Geological Observatory (*P*).	Marine protein resources (krill, fermentation of trash fish, isolation of soluble fish protein) (Oswald Roels, Arthur Chu).
University of Hawaii	Product and process development for utilization of Hawaiian fishes (E. Ross).
SEAFOOD SANITATION AND PRESERVATION	
Oregon State University	Quality improvement and sanitation (David L. Crawford).
University of Rhode Island	Preservation and evaluation of marine foods (H. A. Dymsza, S. M. Constatinides), biochemical changes in fish during storage and processing (H. A. Dymsza), determination of histidine compounds in fishery products (L. E. Ousterhout).
Texas A&M University	Post mortem characteristics and biochemical properties affecting the organoleptic quality of fish muscle (Bryant F. Cobb, Zerle L. Carpenter), role of microorganisms in the quality deterioration of seafoods (Bryant F. Cobb, Carl Vanderzant).
University of Miami	Pathology and virology (lymphocystic disease of fish; age change in snapper muscle viral contamination) (M. M. Siegel).
University of Wisconsin	Bacteria in Great Lakes fishes; pollution, intestinal, and disease bacteria (E. McCoy).
	Management and Preservation of the Marine Environment
POLLUTION	
University of Rhode Island	Waste disposal and pollution control (H. Lampe).
Texas A&M University	Bottom sludge accumulation and oxygen demand in a polluted estuary (Roy W. Hann), biological response to organic chemicals in estuaries (William B. Davis).
University of California, Santa Barbara (*P*).	Chemical determination of source pollutant tars, Santa Barbara Coast, California (Paul G. Mikolaj), microwave radiometric measurements of oil slicks and sea temperature (Norman K. Sanders), effects and implications of petroleum pollutants on resources of the Santa Barbara Channel, phase I—information (Paul G. Mikolaj).
University of Wisconsin	Pathological study of the effects of pesticides on Great Lakes fishes analysis and planning (William E. Ribelin), eutrophication of Green Bay (A. M. Beeton), pesticide level in birds wintering on Lake Michigan (R. S. Ellarson).
Lamont-Doherty Geological Observatory (*P*).	Detecting and relieving pollution effects (Oswald Roels, Pinesh O. Shah).
University of Hawaii	Processes of growth and destruction of coral reefs (K. E. Chave).

Institution	Title and principal
	RESEARCH—Continued
	MANAGEMENT AND PRESERVATION OF THE MARINE ENVIRONMENT—Continued
POLLUTION—Continued	
University of Michigan	Anaerobic digestion and the phosphate problem (J. A. Borchardt), health aspects of Great Lakes waters as related to water supply and recreational uses (John J. Gannon, Edward Armbruster), pollution effects of two-stroke gasoline engine exhaust emission (Walter W. Weber), remote sensing techniques for water pollution detection (C. T. Wezernak), spectroscopic investigations of Great Lakes sediments (Harry B. Mark, Jr.), the biochemistry of the sheath of *Spaerotilus natans* (I. A. Berstein), feasibility study of modeling certain water quality aspects of the Great Lakes (John M. Armstrong), effect of pollution control regulations on watercraft design and operation (John B. Woodward).
NUTRIENTS	
University of Washington	Study of net zooplankton and micronekton (T. S. England), organic budgets of Puget Sound (K. Banse).
University of Rhode Island.	Organic geochemistry of shallow and productive benthic environments (funded below) (J. Quinn).
Texas A&M University	Water and sediment analysis (Frank Chmelik).
University of Wisconsin	Limnological studies of Green Bay (sulfur cycle: phytoplankton) (P. Sager, J. Wiersma), chemistry of phosphate in lower Green Bay (C. F. Lee), chemistry of TEM in Great Lakes waters (C. F. Lee).
University of Michigan	Trace metal fractionation in Lake Michigan (Edward Callendar).
ECOLOGY AND MARINE RESOURCE DEVELOPMENT	
University of Rhode Island	Ecology and economic evaluation of tidal marshes (Nelson Marshall).
University of Michigan	Control theory modeling of aquatic economics systems (Douglas Woodring), the environmental chemical dynamics of sulfur in the Great Lakes (K. H. Mancy), seasonal dynamics of pesticides in western Lake Erie (Rolf Hartung).
University of California, Santa Barbara (*P*).	Fishes of the Santa Barbara Kelp Forest (Alfred W. Ebeling), population dynamics of intertidal organisms (Joseph H. Connell).
University of North Carolina (*P*).	Optimum estuarine ecological systems (Howard T. Odum).
University of Alaska (*P*)	Alaskan marine resources studies (Donald W. Hood).
University of Delaware (*P*).	Influence of climatic water balance on conditions in the estuarine environment (John S. Mather).
Louisiana State University (*P*).	Survey of Barataria Bay for aquaculture development (H. C. Loesch).
Oregon State University	Simulation research in marine productivity (Herbert C. Curl).

Institution	Title and principal
	RESEARCH—Continued
	MANAGEMENT AND PRESERVATION OF THE MARINE ENVIRONMENT—Continued
ENVIRONMENTAL SCIENCE	
University of Miami	Comprehensive study of selected Florida coastal systems (Claes Rooth).
Scripps Institution of Oceanography (*P*).	Air-sea interactions (Carl Gibson, Charles van Atta).
University of California, Santa Barbara (*P*).	Seismicity and earthquakes hazards of the Santa Barbara Channel (Arthur G. Sylvester, Jan D. Rietman).
University of Wisconsin	Circulation studies in large basins (C. H. Mortimer, N. Heaps), circulation studies of Lake Michigan (G. T. Csanady), airborne infrared radiometry (R. A. Ragotzkie), temperature distributions and induced circulation in lakes (John A. Hoopes).
University of Hawaii	Forecasting thermal structure of ocean (C. L. Bretschneider), environmental surveillance and prediction (C. Ramage).
	MINERAL RESOURCES
Texas A&M University	Marine geochemical analysis (for natural gas and petroleum) (William M. Sackett).
University of Rochester (*P*).	Potential fine aggregate sources in Lakes Erie and Ontario (Donald L. Woodrow).
University of Wisconsin	Bathymetric and high resolution shallow subbottom studies, Green Bay (R. P. Meyer), sea floor sediments and depositional processes of economic interest (J. Robert Moore), deep seismic profiling studies of Green Bay (Richard J. Wold).
University of Hawaii	Survey and inventory of sand and deep sea mineral deposits (Mn nodules, phosphorites, diatomaceous ooze, Red Clay, etc.) (G. Sutton, C. L. Bretschneider, Robert Moberly, J. Andrews).
	OCEAN ENGINEERING
University of Washington	Dynamic prediction model of Post Susan (Maurice Rattray, Jr.), system analysis (environmental monitoring systems) (S. R. Murphy), vehicle design research (B. Hartz, H. C. Merchant), marine vessel testing (H. C. Merchant, W. Rogers), marine acoustics program (Stanley Murphy), feasibility studies in various aspects of ocean engineering (H. C. Merchant).
Oregon State University	Applied hydrodynamics (L. S. Slotta), instrumentation—underwater acoustic imaging (L. C. Jensen), industrial engineering—crab and shrimp system standards (William Engesser).
University of Rhode Island	Ocean engineering program (towed instrument and vehicles; instruction panel—textbook; related instrument development—buoys, ocean wave probes, etc.) (F. Middleton).
University of Maryland (*P*).	Heat transfer system for deep submersibles (S. T. Hsu).

Institution	Title and principal
	RESEARCH—Continued
	OCEAN ENGINEERING—Continued
Texas A&M University	Measuring drag forces produced by wave action on piles (Robert M. Sorenson), reduction of pump cavitation in dredging (John B. Herbich), analytical solution for the dynamic response of the laterally loaded pile (Thomas C. Edwards, Harry M Coyle), scour of gulf coast sand beaches due to wave action in front of sea walls and dune barriers (R. W. Schiller, Jr.), nuclear activation analysis of deep sea core samples (R. E. Wainerdi), acoustic communications (Stephen Riter), shear strength determination of marine sediments (William R. Bryant).
Stevens Institute of Technology (*P*).	Forces and motions induced by waves on floating moored ocean platforms and supplementary studies on wave phenomena of importance to platform design (John P. Breslin).
University of Miami	Materials in the sea: corrosion, biodeterioration, fouling, borer control, physical and electrical properties of organic materials, turbulent velocity and marine propulsion (Kenneth G. Compton).
University of Michigan	Underwater operations program (Jack L. Hough), study of the mechanics of circulating currents in Lake Michigan (J. C. Ayers, F. C. Poecyn), very large intra-lake bulk carrier feasibility study (R. A. Yagle).
University of Wisconsin	Development of a vibratory coring device (R. J. Harker), gravity waves and their dynamic interaction (Peter L. Monkemeyer, T. Green, W. Saul), dynamics of underwater structure systems and structure members (T. C. Huang), engineering characteristics of Green Bay bottom characteristics (G. L. Roderick), corrosion studies of construction materials in reducing sediments (John N. Ong, Jr., R. G. Gilliland), underwater body dynamics (Ali A. Seirig), investigation of and extractive methods for Green Bay minerals (R. W. Heins, T. T. Tiemann).
University of Delaware (*P*).	Systems engineering of mollusc production and ocean engineering curriculum development (Wm. S. Gaither), physical stimuli and energy requirements for separating valves of oysters (Thomas H. Williams).
University of Hawaii	Development of 200 meter depth simulator; engineering service for mineral survey (C. L. Bretschneider).
	MARINE SOCIO-ECONOMICS
University of Washington	Socio-economic and legal considerations for managing Puget Sound (J. A. Crutchfield).
Oregon State University	Demands, prices, and marketing; economics of coastal areas; public policy in the seafood industry (E. N. Castle).

Institution	Title and principal
	RESEARCH—Continued
	MARINE SOCIO-ECONOMICS—Continued
University of Michigan	Economic and institutional interdependencies in choosing water management strategies (the Huron River basin) (Ralph A. Luken), computer simulation of institutional interaction (J. W. Bulkley), shoreline land use development of the Great Lakes (K. J. Polakowski).
University of Rhode Island	Simulation of dynamic properties of interacting commercial fisheries; economic impact of conflicting marine resources use; bio-economic model for lobster fishery exploitation schemes; distribution network for fishery products (N. Rorholm).
Texas A&M University	Economic study of shrimp industry (R. Thompson), assessment and projection of marine oriented economic activities in the development of Texas Gulf coast (J. R. Bradley, E. V. Bowden, R. G. Thompson).
University of Miami	Socio-economic studies on seafood and sport fishing resources (R. J. Hensley).
Scripps Institution of Oceanography (*P*).	Resource economics (M. B. Schaefer).
Louisiana State University (*P*).	Economic impact of marine and coastal resources on Louisiana economy (R. L. Burford).
University of California Santa Barbara (*P*).	Economic evaluation of ocean mineral resource development and related public policy issues (W. J. Mead, P. E. Sorensen).
University of Wisconsin	Overseas shipping at Great Lakes ports and projections for future (E. Schneker), application of a conceptual systems model to determine the economic impact of Lake Michigan on the recreation industry in Door County, Wis. (W. A. Strang), advanced studies center (J. Steinhart), Green Bay research program (V. L. Arnold), evaluation of uses of land created by disposal of dredging spoils in Great Lakes basins and coastal seaboard areas (H. C. Brockel), design of general decision-making model for public decision-making relative to the estuaries of the United States (W. B. Lord).
University of Hawaii	Economic analysis of the fisheries industry (J. Davidson, C. Gopalakrishnan, S. Comitini), economics of alternative use of marine resources (J. Davidson, J. Keeler, C. Gopalakrishnan), economic feasibility study of marine resources (J. Davidson, H. Yamauchi).
	MARINE RESOURCE LAW
University of Washington	Planning of ocean resource law program (W. I. Burke).
Oregon State University	Ocean resources law periodical teaching and research in ocean resources law (J. L. Jacobson, C. D. Clark).
University of Rhode Island	Law of the Sea Institute (L. Alexander, D. Wilkes).

Institution	Title and principal
	RESEARCH—Continued
	MARINE RESOURCE LAW—Continued
University of Miami	Coastal region law (Dennis O'Connor).
Louisiana State University (*P*).	Compilation and systematization of Louisiana laws affecting estuaries and marshes (H. G. Knight).
University of Maine (*P*)	Maine marine resources law (D. J. Halperin).
	MISCELLANEOUS
University of Washington	Catalog of oceanographic data of Puget Sound (C. A. Barnes, A. C. Duxbury, T. S. English, G. C. Anderson), utilization of marine plant polymers (G. G. Allan, K. V. Sarkanan).
University of Michigan	Development of new applications (J. McFadden), resource management systems studies (J. McFadden).
University of Wisconsin	New research projects and applications (R. Ragotzkie).
Texas A & M University	Development of new marine resource projects (J. Calhoun).
University of Hawaii	Diving physiology (T. A. Rogers).
	ADVISORY SERVICES [2]
University of Washington	Continuing education for technologists (J. Liston), fishing industry conference (R. Van Cleve), public information exhibits and programs (Dixy Lee Ray), advisory services within the division of marine resources (S. R. Murphy).
Oregon State University	General advisory services, including centralized information center, public education, publications and intensive extension service (W. Q. Wick).
University of Rhode Island	NEMRIP (information center, extension and services, industrial development) fisheries extension (W. Gray, J. Sainsbury).
Texas A & M University	Extension and advisory services; marine resources information center (J. E. Hutchinson, E. B. Smith).
University of Miami	Advisory services: Gulf and Caribbean fisheries (C. P. Idyll), educational bulletins (J. Michel), decision seminars (D. O'Connor), economic services (W. Suojanen).
University of Wisconsin	University extension, university-industry research (G. D. Hedden).
University of Delaware	Technical training and extension services (S. Gwinn).
University of Hawaii	Advisory services.
University of Michigan	Advisory services (J. McFadden).
Scripps Institution of Oceanography (*P*).	Advisory services.

[1] Most technician training programs include curriculum development, course improvement or initiation, faculty recruitment and equipment purchase.

[2] All Sea Grantees conduct advisory service activity consistent with the type of grant. Minimum service is publication of results. Listed are major activities under directors responsible for specifically funded advisory service programs.

APPENDIX F—HYPERBARIC FACILITIES IN THE UNITED STATES

NORTHWEST

Fairchild Air Force Base	Spokane, Wash.
U.S. Navy Torpedo Station	Keyport, Wash.
Tug Salvage Chief	Astoria, Oreg.
Hocket Lester Co	Seattle, Wash.
Brownlee Dam	Brownlee, Oreg.
McNary Dam	Umatilla, Oreg.

SOUTH

U.S. Air Force School of Aerospace Medicine, Brooks Air Force Base	San Antonio, Tex.
NASA Manned Spacecraft Center	Houston, Tex.
Deep Sea Diver, Inc	Belle Chasse, La.
Bailey Marine Diving Service	Patterson, La.
Ocean Systems	Morgan City, La.
Divcon, Inc	Morgan City, La.
Deep Sea Divers, Inc	Grand Isle, La.
Sanford Marine Services	Bewick, La.
World Wide Divers	Bayon Vista, La.
Hydrotech Service Inc	Harahan, La.
Global Divers & Contractors, Inc	Westwego, La.
Taylor Diving & Salvage Co., Inc	New Orleans, La.
Dr. Linwood Hugh Carter	New Orleans, La.
Dick Evans Professional Divers	Harvey, La.
Pelican Marine Diving Service	Harvey, La.
Deep Sea Divers, Inc	Belle Chasse, La.
Marine Diving Services	Corpus Christi, Tex.
J & J Marine	Pasadena, Tex.
U.S.S. *Cabrillo* (AGSS–288)	Brady Island, Houston, Tex.
Hydrotech Services, Inc	Freeport, Tex.

EAST

Mount Sinai Hospital	New York, N.Y.
Veterans' Administration Hospital	Buffalo, N.Y.
State University of New York	Buffalo, N.Y.
Millard Filmore Hospital	Buffalo, N.Y.
University of Pennsylvania	Philadelphia, Pa.
University of Maryland	Baltimore, Md.
U.S. Navy Medical Research Institute	Bethesda, Md.
EOD Technical Center	Indian Head, Md.
U.S. Navy Deep Sea Diving School	Washington, D.C.
U.S. Army Transportation School	Fort Eustis, Va.
Comm Sublant	Norfolk, Va.
Duke University Medical Center	Durham, N.C.
Charleston Naval Shipyard	Charleston, S.C.
U.S.S. *Kittywake* (ASR–13)	Norfolk, Va.
U.S. Navy Underwater Demolition Team 21	Little Creek, Va.
U.S. Naval Station	Solomons Island, Md.
Comservron Eight	Norfolk, Va.
U.S.S. *Orion* (AS–18)	Norfolk, Va.
Physiology Training Unit	Beaufort, S.C.

APPENDIX F—HYPERBARIC FACILITIES IN THE UNITED STATES—Continued

SOUTHWEST

Pacific Grove Fire Department	Pacific Grove, Calif.
Coastal Diving School	Oakland, Calif.
Bay Area Rapid Transit	San Francisco, Calif.
U.S.S. *Gear* (ARS-34)	San Pedro, Calif.
Naval Ordnance Test Station	San Clemente Island, Calif.
Second Class Diver School, U.S. Naval Station	San Diego, Calif.
Long Beach Naval Shipyard	Long Beach, Calif.
International Divers	Goleta, Calif.
U.S. Navy Amphibious Base, Coronado	San Diego, Calif.
California Divers	Santa Barbara, Calif.
General Offshore Divers, Inc	Santa Barbara, Calif.
Point Mugh Navy Air Station	Santa Barbara, Calif.
Naval Shipyard, Hunter's Point	San Francisco, Calif.
Presbyterian Medical Center	San Francisco, Calif.
Castle Air Force Base	Merced, Calif.
Hospital of the Good Samaritan	Los Angeles, Calif.

MIDWEST

Minneapolis Medical Research Foundation	Minneapolis, Minn.
St. Luke's Hospital	Milwaukee, Wis.
Presbyterian-St. Luke's Hospital	Chicago, Ill.
St. James Hospital	Chicago, Ill.
Lutheran General Hospital	Park Ridge, Ill.
Wright-Patterson AFB, Ohio	Dayton, Ohio
Maumee Valley Hospital	Toledo, Ohio.
Milwaukee County General Hospital	Milwaukee, Wis.
Hennepin County General Hospital	Minneapolis, Minn.
U.S.S. *Cod*	Cleveland, Ohio.

SOUTHEAST

Navy Mine Defense Laboratory	Panama City, Fla.
Naval Ordinance Lab Test Facility	Fort Lauderdale, Fla.
Fort Lauderdale	Fort Lauderdale, Fla.
Underwater Swimmers School	Key West, Fla.

NORTHEAST

Portsmouth Naval Shipyard	Kittery, Maine.
Harvard University	Cambridge, Mass.
Boston Children's Hospital	Boston, Mass.
Boston Naval Shipyard	Boston, Mass.
Otis Air Force Base	Falmouth, Mass.
Naval Ordinance Test Station	Newport, R.I.
Submarine Base	New London, Conn.
St. Barnabas Medical Center	Newark, N.J.

CANADA

Vancouver General Hospital	Vancouver, British Columbia, Canada.
Toronto General Hospital	Toronto, Ontario, Canada.
Royal Victoria Hospital	Montreal, Quebec, Canada.

APPENDIX F—HYPERBARIC FACILITIES IN THE UNITED STATES—Continued

WESTERN PACIFIC

Yokosuka, Japan-United States Navy Ship Repair Facility	Yokosuka, Japan.
B.C.C. British Naval Station, HMS *Tamar*	Hong Kong.
U.S. Navy Ship Repair Facility (Divers School)	Subic Bay, Philippine Islands.
Pacific Missile Range Facility	Kwajalein Island.
U.S. Navy fleet activities	Sasebo, Japan.
Explosive Ordinance Disposal Unit 1	Pearl Harbor, Hawaii.

NAVY ATLANTIC FLEET SERVICE FORCE SHIPS

U.S.S. *Escape* (ARS–6)	San Juan, P.R.
U.S.S. *Preserver* (ARS–8)	Norfolk, Va.
U.S.S. *Hoist* (ARS–40)	Norfolk, Va.
U.S.S. *Opportune* (ARS–41)	Norfolk, Va.
U.S.S. *Recovery* (ARS–43)	Norfolk, Va.

NAVY SUBMARINE FORCE ATLANTIC FLEET SHIPS

U.S.S. *Sunbird* (ARS–15)	New London, Conn.
U.S.S. *Tringa* (ARS–16)	New London, Conn.
U.S.S. *Skylark* (ARS–16)	New London, Conn.
U.S.S. *Kittiwake* (ARS–13)	Norfolk, Va.
U.S.S. *Petrel* (ARS–14)	Charleston, S.C.
U.S.S. *Penguin* (ARS–12)	Key West, Fla.
U.S.S. *Fulton* (AS–11)	New London, Conn.
U.S.S. *Orion* (AR–18)	Norfolk, Va.
U.S.S. *H.W. Gilmore* (AS–16)	Charleston, S.C.
U.S.S. *Hunley* (AS–31)	Charleston, S.C.
U.S.S. *Holland* (AS–32)	Charleston, S.C.
U.S.S. *Simon Lake* (AS–33)	Charleston, S.C.
U.S.S. *Canopus* (AS–34)	Charleston, S.C.
U.S.S. *Bushnell* (AS–15)	Key West, Fla.

APPENDIX G—U.S. OCEANOGRAPHIC SHIPS AND UNDERSEA VEHICLES

Appendix G-1—U.S. Oceanographic Ships*

A. Government

Ship name and designator	Length (feet)	Tonnage	Crew	Scientists	Year built	Mission
Department of Commerce						
ESSA (Coast and Geodetic Survey):						
Discoverer (OSS-02)	303	3, 959	87	17	1966	Oceanographic research.
Oceanographer (OSS-01)	303	3, 959	87	17	1966	Do.
Surveyor (OSS-32)	292	3, 150	90	8	1960	Oceanographic research/hydrographic surveying.
Researcher (OSS-03)	278	2, 800	69	7	1970	Oceanographic research.
Fairweather (MSS-20)	231	1, 660	77	4	1967	Hydrographic survey.
Mt. Mitchell (MSS-22)	231	1, 660	77	4	1967	Do.
Rainier (MSS-21)	231	1, 660	77	4	1967	Do.
Pathfinder (OSS-30)	229	2, 000	83	4	1942	Do.
Davidson (CSS-31)	175	995	36	2	1967	Do.
McArthur (CSS-30)	175	995	36	2	1967	Do.
Peirce (CSS-28)	164	760	36	2	1962	Do.
Whiting (CSS-29)	164	760	36	2	1962	Do.
Ferrel (ASV-92)	133	363	17	2	1968	Current surveys.
Heck (ASV-91)	90	214	10	0	1966	Wire drag vessel
Rude (ASV-90)	90	214	10	0	1966	Do.
Launch 1255	59	41	1	2	1968	High-speed hydrographic sounding boat and buoy tender.
Launch 1257	59	41	1	2	1968	High-speed hydrographic sounding boat.
Department of Defense						
U.S. Navy:						
MSTS (for OCEANAV):						
Michelson (T-AGS-23)	455	13, 050	86	17	1945	General oceanography and hydrography.
Bowditch (T-AGS-21)	455	13, 050	86	17	1945	Do.

See footnote at end of table.

APPENDIX G—U.S. OCEANOGRAPHIC SHIPS AND UNDERSEA VEHICLES—Continued

Appendix G-1—U.S. Oceanographic Ships—Continued

A. Government—Continued

Ship name and designator	Length (feet)	Tonnage	Crew	Scientists	Year built	Mission
Department of Defense—Continued						
U.S. Navy—Continued						
MSTS (for OCEANAV)—Continued						
Dutton (T–AGS–22)	455	13, 050	86	17	1945	General oceanography and hydrography.
Chauvenet (T–AGS–29)	393	4, 200	69	12	1970	Hydrographic survey.
Harkness (T–AGS–32)	393	4, 200	69	12	1970	Do.
Sgt. Geo. D. Keathley (T–AGS–35)	338	6, 090	43	15	1944	Gravity and magnetic survey.
Silas Bent (T–AGS–21)	285	2, 580	44	34	1965	Hydrographic survey.
Elisha Kane (T–AGS–27)	285	2, 489	48	30	1966	Do.
Wilkes (T–AGS–33)	285	2, 600	50	30	1970	Do.
Wyman (T–AGS–34)	285	2, 600	43	28	1971	Do.
Hayes (T–AGOR–16)	246	3, 100	44	25	1971	Do.
Kellar (T–AGS–25)	208	1, 334	29	13	1969	Do.
Bartlett (T–AGOR–13)	208	1, 325	27	15	1969	General oceanography.
Charles H. Davis (T–AGOR–5)	208	1, 300	27	15	1963	Do.
DeSteiguer (T–AGOR–12)	208	1, 325	27	15	1969	Do.
James M. Gilliss (T–AGOR–4)	208	1, 300	27	15	1962	Do.
Lynch (T–AGOR–7)	208	1, 300	27	15	1965	Do.
Sands (T–AGOR–6)	208	1, 300	27	15	1964	Do.
S. P. Lee (T–AGS–31)	208	1, 338	28	13	1968	Hydrographic survey.
MSTS (for Naval Research Lab):						
Mission Capistrano (T–AG–162)	523	17, 340	60	15	1943	Marine acoustics.
J. W. Gibbs (T–AGOR–1)	311	2, 800	48	28	1944	Oceanographic research.
Mizar (T–AGOR–11)	266	3, 500	40	19	1957	Do.
MSTS (for NASA). See NASA.						
MSTS (for NSF). See National Science Foundation.						
Naval Research Lab:						
X–1 (SSX–1)	50	31	4	2	1965	Oceanographic research.

Undersea R&D Center (Pasadena):						
YFU-44 [1]	119	274	10	....	1944	Equipment test vessel.
Arctic Research Laboratory:						
Natchik	38	16	1	3	1959	General oceanography.
Postgraduate School:						
R.V	63	35	4	4	1963	Research and training.
Underwater Weapons Station (Newport):						
News (*IX-306*) (*Ex AKL-221*)	180	800	21	6	1945	Equipment test and evaluation (contractor operated-RCA) for AUTEC.
Department of the Interior						
Bureau of Commercial Fisheries:						
Pribilof	222	1,893	19	....	1954	Cargo ship; Seal Management program.
Miller Freeman	214	1,782	24	9	1967	Fisheries research.
Albatross IV	187	1,060	19	13	1962	Do.
George B. Kelez	176	515	14	6	1944	Do.
David Starr Jordan	171	890	16	17	1965	Do.
Oregon II	170	906	14	11	1967	Fishing and fisheries research.
Townsend Cromwell	158	565	13	10	1963	Fisheries research.
Delaware II	155	720	15	6	1968	Do.
Charles H. Gilbert	123	383	16	....	1952	Do.
Oregon	100	410	12	7	1946	Do.
John N. Cobb	93	185	7	4	1950	Do.
Murre II	86	264	3	6	1943	Do.
George M. Bowers	74	125	14	6	1955	Oceanographic research.
Siscowet	67	43	2	3	1946	Fisheries research.
Rorqual	65	78	3	3	1942	Do.
Kaho	65	82	3	3	1961	Do.
Miss Behavior	63	25	1	6	1943	Fisheries technology.
Cisco	60	75	4	5	1951	Fisheries research.
Heron	58	70	3	2–4	1940	Do.
Shang Wheeler	51	41	2	4	1951	Do.
Alosa	48	20	2	2–4	1939	Do.
Hiodon	45	35	2	2	1965	Fish gear research.
Musky II	45	25	2	3	1960	Fisheries research.
Kingfish	43	....	1	3	1954	Do.
Phararope II	40	16	1	2–4	1932	Do.

See footnote at end of table.

APPENDIX G—U.S. OCEANOGRAPHIC SHIPS AND UNDERSEA VEHICLES—Continued

Appendix G-1—U.S. Oceanographic Ships—Continued

A. Government—Continued

Ship name and designator	Length (feet)	Tonnage	Crew	Scientists	Year built	Mission
Department of the Interior—Continued						
Bureau of Mines:						
Virginia City (loaned to Navy)	205	1, 235	20	20	1943	Marine mining technology.
Cripple Creek	65	95	3	5	1953	Do.
Bureau of Sport Fisheries and Wildlife:						
Dolphin	107	390	10	7	1953	Marine game fish research.
Challenger	65	48	3	4	1942	Diver support.
Seawind	36	10	1	2	1952	Research support.
Federal Water Pollution Control Administration:						
Clean Waters	65	39	3	3–35	1967	Estuarine monitoring.
H. W. Streeter	45	....	1	2–3	1962	Do.
Geological Survey:						
Donald J. Miller II	118	284	3	12	1937	Coastal geology.
Polaris	96	57	5	6	1927	Marine geology.
Department of Transportation						
Coast Guard:						
Rockaway (WAGO–377)	311	2, 800	120	18	1942	General oceanography.
Glacier (WAGB–4)	310	8, 449	230	20	1954	Arctic oceanography (icebreaker).
Burton Island (WAGB–283)	269	6, 515	194	10	1946	Do.
Edisto (WAGB–284)	269	6, 515	194	10	1947	Do.
Northwind (WAGB–282)	269	6, 515	194	10	1945	Do.
Southwind (WAGB–280)	269	6, 515	194	10	1943	Do.
Staten Island (WAGB–278)	269	6, 515	194	10	1944	Do.
Westwind (WAGB–281)	269	6, 515	194	10	1944	Do.
Acushnet (WAGO–167)	213	1, 745	72	7	1943	General oceanography.
Evergreen (WAGO–295)	180	1, 025	52	8	1943	Do.

378-foot WHEC (Secretary class)	378	2, 750	141	3	1966–70	Ocean station vessels with research capabilities.
Boutwell (WHEC–719).						
Chase (WHEC–718).						
Dallas (WHEC–716).						
Gallatin (WHEC–721).						
Hamilton (WHEC–715).						
Jarvis (WHEC–724).						
Mellon (WHEC–717).						
Midgette (WHEC–726).						
Morgenthau (WHEC–722).						
Munroe (WHEC–725).						
Rush (WHEC–723).						
Sherman (WHEC–720).						
327-foot WHEC (Secretary class)	327	2, 827	144	3	1936–37	Ocean station vessels with research capabilities.
Bibb (WHEC–31).						
Campbell (WHEC–32).						
Duane (WHEC–33).						
Ingham (WHEC–35).						
Spencer (WHEC–36).						
Taney (WHEC–37).						
311-foot WHEC (seaplane tender class)	311	2, 800	148	3	1941–44	Ocean station vessels with research capabilities.
Absecon (WHEC–374).						
Castle Rock (WHEC–383).						
Chincoteague (WHEC–375).						
Cook Inlet (WHEC–384).						
McCulloch (WHEC–386).						
255-foot WHEC (lake class)	255	1, 913	137	3	1945–46	Ocean station vessels with research capabilities.
Androscoggin (WHEC–68).						
Chautauqua (WHEC–41).						
Escanaba (WHEC–64).						
Klamath (WHEC–66).						
Mendota (WHEC–69).						
Minnetonka (WHEC–67).						
Owasco (WHEC–39).						
Ponchartrain (WHEC–70).						
Sebago (WHEC–42).						
Wachusett (WHEC–44).						

See footnotes at end of table.

APPENDIX G—U.S. OCEANOGRAPHIC SHIPS AND UNDERSEA VEHICLES—Continued

Appendix G-1—U.S. Oceanographic Ships—Continued

A. Government—Continued

Ship name and designator (if any)	Length (feet)	Tonnage	Crew	Scientists	Year built	Mission
Department of Transportation—Continued						
Coast Guard—Continued						
255-foot WHEC—Continued						
Winnebago (WHEC–40).						
Winona (WHEC–65).						
Miscellaneous						
HEW (Public Health Service):						
B. W. Brown	60	40	2	2	1937	Estuary research.
NASA (Range instrumentation ships—operated for NASA by MSTS):						
Redstone (T–AGM–20)	596	19, 770	87	54	1966	
Vanguard (T–AGM–19)	596	19, 770	90	107	1966 [3]	
Gen. H. H. Arnold (T–AGM–9)	522	17, 120	100	105	1944–62 [3]	
Gen. H. S. Vandenberg (T–AGM–10)	522	17, 120	100	105	1944–62 [3]	
Huntsville (T–AGM–7)	455	11, 860	63	40	1966 [3]	
Longview (T–AGM–3)	455	11, 295	53	16	1961 [3]	
Sonnyvale (T–AGM–5)	455	11, 295	53	14	1961 [3]	
Watertown (T–AGM–6)	455	11, 860	63	40	1966 [3]	
Wheeling (T–AGM–8)	455	11, 295	63	45	1963 [3]	
Sword Knott (T–AGM–13)	339	5, 150	42	15	1961 [3]	
Range Recoverer (T–AGM–2)	176	615	22	8	1960 [3]	
National Science Foundation:						
Eltanin (T–AGOR–8) (MSTS operated)	272	3, 886	48	38	1957	Oceanographic research.
Hero (contractor operated)	125	650	11	11	1968	Antarctic oceanograhic research.

See footnote at end of table.

B. Universities, Colleges, Etc.

Ship name and designator	Length (feet)	Tonnage	Crew	Scientists	Year built	Mission
California Maritime Academy:						
Golden Bear	425	6, 740	50	250	1945	General oceanography and training.
Cape Fear Technical Institute:						
Advance II	185	975	35	15	1944	Oceanographic technology and training.
W. Dallas Herring (Ex CG Tug)	110	199	9	10	1933	General oceanographic research.
Tar 6	65	95	5	4	1953	Oceanographic technology and training.
College of Marin:						
P. T. Wilson	31	....	2	2	1940	General estuarine research.
Columbia University Lamont-Doherty Geological Observatory):						
Robert D. Conrad (AGOR–3)	208	1, 370	21	22	1962	Oceanographic research.
Vema	202	743	20	18	1922	Do.
Sir Horace Lamb	136	320	15	8	1942	Do.
Erline	100	120	5	....	1965	Argus Island personnel transfer and support.
T–426	65	95	5	4	1953	Nearshore survey and test.
Columbia School of Mines:						
Manning (Ex U.S. Army T–514)	65	95	4	3	1954	Coastal research.
Duke University:						
Eastward	117	474	15	15	1964	General oceanography.
Florida State University:						
Tursiops	65	95	2	6	1959	General nearshore oceanography.
Hawaiian Institute of Geophysics:						
Mahi	185	1, 325	14	16	1944	Oceanographic research.
Teritu (see Research Corp of the U. of Hawaii Section C.)						

APPENDIX G—U.S. OCEANOGRAPHIC SHIPS AND UNDERSEA VEHICLES—Continued

Appendix G-1—U.S. Oceanographic Ships—Continued

B. Universities, Colleges, Etc.—Continued

Ship name and designator	Length (feet)	Tonnage	Crew	Scientists	Year built	Mission
Humboldt State College:						
Sea Gull	39	14	4	4	1937	General nearshore oceanography.
Johns Hopkins University:						
Ridgely Warfield	106	262	8	10	1967	Oceanographic research.
Maury	65	40	3	4	1950	Do.
Lydia Louise	40	10	1	1	1957	Do.
Lehigh University:						
Mysid	20	1	1	2	1968	General estuarine research.
Long Island University-Southampton College:						
Photoma	38	12	....	....	....	Estuary research.
Paumanok	28	8	....	....	....	Do.
Maritime College of the State University of New York:						
Empire State IV	489	15, 470	105	462	1962	General oceanography and training.
New York University:						
Kyma	65	100	3	1	1952	General oceanography.
Northwestern Michigan College:						
Allegheny	143	860	40	6	1944	General limnology.
Nova University:						
Gulf Stream	55	29	....	....	1963	Nearshore research.
Bellows	63	48	....	....	1968	Do.
Old Dominion University:						
Albatross	63	45	2	5	1945	Biological oceanography.

Oregon State University:						
Yaquina	180	666	17	20	1944	Oceanographic research.
Cayuse	80	164	7	8	1968	Oceanographic research.
Sacajawea	37	7	1	5	1969	Nearshore oceanography and Columbia River work.
Paiute	33	7	1	4	1966	Nearshore/estuary research.
Pennsylvania State Colleges (marine science consortium):						
Catamaran	34	.....	1	12	1969	Ocean research and training.
Lydia B	30	.....	1	6	1936	Do.
Scripps Institution of Oceanography (University of California at San Diego):						
Flip	355	2, 100	6	8	1962	Stable oceanographic platform.
Samuel Melville (AGOR–14)	245	2, 025	25	26	1969	Oceanographic research.
Thomas Washington (AGOR–10)	208	1, 362	23	15	1965	Do.
Alexander Agassiz	180	825	17	18	1944	Do.
Alpha Helix	133	512	12	14	1966	Marine biology.
Oconostota	100	206	8	6	1944	Oceanographic research.
Ellen B. Scripps	95	234	5	8	1965	Do.
ST–908	45	28	1	4	1945	Nearshore research.
Southeastern Massachusetts University:						
Corsair	65	48	2	5	1942	General oceanography and training.
Stanford University—Hopkins Marine Station:						
Proteus	100	186	7	9	1946	Oceanographic research.
Tage	40	3	1	8	1934	Do.
Texas A & M University:						
Alaminos	180	850	17	18	1945	Do.
University of Alabama:						
J-Boat	36	....	2	12	1945	Nearshore oceanography.
University of Alaska:						
Acona	80	154	6	9	1961	Oceanographic research.
University of Arizona:						
(Unnamed)	24	1	1	3–4	1961	Marine biology.
University of California at San Diego. (See Scripps Institution of Oceanography.)						

APPENDIX G—U.S. OCEANOGRAPHIC SHIPS AND UNDERSEA VEHICLES—Continued

Appendix G-1—U.S. Oceangraphic Ships—Continued

B. Universities, Colleges, Etc.—Continued

Ship name and designator	Length (feet)	Tonnage	Crew	Scientists	Year built	Mission
University of Connecticut:						
T-441	65	99	9	9	1953	General nearshore oceanography.
University of Delaware:						
Wolverine	52	20	2	3	1946	General estuarine oceanography.
University of Florida:						
Urchin	32	.....	....	....	....	Light bottom sampling and trawling.
University of Georgia:						
Kit Jones	64	23	3	4	1938	Estuary oceanography.
Striker	33	10	2	2	1961	Estuary biology.
University of Maine:						
Miss Bess	34	14	2	2	1967	Nearshore oceanography.
Catamaran Cypris	34	8	2	4	1970	Do.
University of Miami:						
John Elliott Pillsbury	176	560	25	15	1944	Oceanographic research.
Gerda	75	160	2	8	1949	Do.
University of Michigan:						
Inland Seas	114	500	9	10	1943	General limnology.
Mysis	50	35	2	3	1963	Do.
University of North Carolina:						
Macapunga	47	20	2	2	1954	General nearshore oceanography.
University of the Pacific:						
Black Swan	39	121	3	....	1961	Nearshore oceanographic research.
Princess	32	18	2	....	1938	Nearshore biology.

University of Rhode Island:						
Trident	180	860	20	13	1942	Oceanographic research.
Gail Ann	45	....	1	6	....	Fisheries training.
Billie II	45	....	1	6	....	Nearshore oceanography.
University of Southern California:						
Velero IV	110	580	11	9	1948	Oceanographic research.
Golden West	43	14	2	4	1953	Research/hydrography.
University of Texas:						
Marcia K	55	....	2	6	1959	Estuarine and shelf oceanography.
Lorene	44	10	1	1	1940	Nearshore sampling programs.
Flat Cat II	40	....	1	2	1968	Coring vessel.
Bevo	21	....	1	2	1966	Estuary oceanography.
Prairie Schooner	19	2	1	4	1968	Estuary research.
University of Washington:						
Thomas G. Thompson (AGOR–9)	208	1, 362	23	18	1965	Oceanographic research.
Commando	67	69	3	6	1944	Fisheries biology and training.
Hoh	65	91	2	4	1943	Inshore oceanographic research.
Onar	65	95	2	6	1954	Inshore fisheries biology.
Virginia Institute of Marine Science:						
Langley	76	109	3	10	1952	Inshore biology and oceanography.
Pathfinder	55	51	2	4	1957	Do.
Woods Hole Oceanographic Institution:						
Knorr (AGOR–15)	245	2, 300	25	25	1970	Oceanographic research.
Chain (AGOR–17)	213	2, 100	33	25	1944	Do.
Atlantis II	210	2, 300	31	25	1962	Do.
Crawford	125	300	12	8	1927	Laid Up-Inactive status.
Lulu	96	400	9	15	1965	Deep submersible mother ship.
Gosnold	99	300	9	8	1944	Oceanographic research.
V.I.P. Flyer	64	40	2	10	1966	Coastal research.
Asterias	40	12	1	3	1931	General nearshore oceanography.

APPENDIX G—U.S. OCEANOGRAPHIC SHIPS AND UNDERSEA VEHICLES—Continued

Appendix G-1—U.S. Oceanographic Ships—Continued

C. Industrial/Commercial

Ship name and designator (if any)	Length (feet)	Tonnage	Crew	Scientists	Year built	Mission
AC Electronics, General Motors Corp.:						
Pop	233	55–115	......	4	1966	Stable oceanographic platform.
Swan	137	365	8	17	1944	Research, test, and support.
Retriever	56	35	2	....	....	Research support.
Alpine Geophysical Associates, Inc.:						
Ruth Ann	180	830	20	9	1944	Geophysical survey.
Santa Maria	180	825	18	9	1945	Do.
Green Hornet	37	85	1	2	1965	Research/survey support.
Aqua Marine Service:						
Blue Marlin	150	965	12	12	....	Offshore support vessel.
Beaudette Foundation for Biological Research:						
Neptunus Rex	97	400	7	6	1962	General oceanographic.
The Bermuda Biological Station for Research, Inc.:						
Panulius II	64	....	3	6	1961	Biological oceanography.
Braincon, Inc.:						
Oceanonics I	23	4	1	2	1960	Equipment and instrument test.
State of California, Department of Fish and Game:						
N.B. Scofield	101	168	9	3	1938	Fisheries research.
Alaska	100	272	2	13	1947	Exploratory fishing.
Camden Dory Co.:						
Big Cat	36	15	1	2	1950	Exploratory trawling.
Coastal Marine Associates, Inc.:						
Peggy G	182	199	9	....	1966	Submarine cableship.

Decca Survey Systems, Inc.:						
Launch	22	2	1	1	1969	High-speed hydro survey.
Deepsea Ventures, Inc.:						
Prospector	152	6, 600	9	9	1963 [3]	Research/survey.
Deepsea Miner	322	7, 500	15	50	1970 [3]	Prototype mining.
Edwin A. Link:						
Sea Diver II	91	158	3	8	1959	General oceanography.
Frank A. Sundell Associates:						
Pacific Surveyor	110	130	6	17	1943	Do.
General Marine Transport:						
Sea Systems	135	192	4	8	1964	Offshore support.
Sea Transport	135	192	4	8	1964	Do.
Winn	127	115	3	10	1959	Do.
Cameron	120	115	3	4	1958	Do.
Packer	65	84	2	2	1959	Research.
Sea Truck	65	68	2	2	1960	Offshore support.
General Oceanographics, Inc.:						
Lady	81	....	3	4–8	1939	Support for submersible *Nekton*.
Dawn Star	52	41	3	3	65	Geophysics survey, general oceanography, submersible support.
Georex Inc.:						
Arctic Seal	165	290	7	15	1965	Geophysical surveys.
George R. Walton & Co.:						
Southern Venture	72	115	3	....	1957	Diving and salvage.
Noa	31	....	2	....	1970	Magnetic survey.
Global Marine, Inc.:						
Glomar Challenger	400	10, 500	18	52	1968	Deep water drill ship
Glomar Grand Isle	400	11, 200	18	42	1967	Do.
Glomar Conception	400	11, 200	18	42	1967	Do.

APPENDIX G—U.S. OCEANOGRAPHIC SHIPS AND UNDERSEA VEHICLES—Continued

Appendix G-1—U.S. Oceanographic Ships—Continued

C. Industrial/Commercial—Continued

Ship name and designator (if any)	Length (feet)	Tonnage	Crew	Scientists	Year built	Mission
Global Marine, Inc—Continued						
Glomar Sirte	380	9, 550	21	25	1965	Do.
Glomar Tasman	380	9, 550	21	25	1965	Do.
Glomar North Sea	380	9, 550	21	25	1965	Do.
Glomar II	267	5, 800	18	30	1962	Medium depth drill ship.
Glomar III	267	5, 800	18	30	1962	Do.
Glomar IV	267	5, 800	18	30	1962	Do.
Glomar V	267	5, 800	18	30	1963	Do.
Cuss I	258	1, 870	4	36	1956	Drilling barge.
Rincon	204	1, 300	....	....	....	Do.
Western Explorer	204	1, 500	....	....	....	Deep water drill ship.
La Ciencia	136	250	....	....	....	Shallow water drill ship.
Guzzetta Offshore Marine Service, Inc.:						
Midnight Worker	178	1, 050	10	6	1969	Geophysical exploration.
Midnight Sun	128	750	8	18	1965	Do.
Honeywell Marine Systems Center:						
Ocean Twin	81	170	3	8	1966	Underwater acoustic research and development.
Response	65	95	2	6	1952	Do.
Neper	48	23	2	4	1955	Do.
Hydrospace Research Corp.:						
Daniel L. Harris III (Ex PC–1140)	173	296	14	14	1943	Oceanographic research.
Patrick Kiley (Ex PC–567)	173	296	14	14	1942	Do.

Infinity, Ltd.:						
(Unknown) Houseboat	36	6	2	6	1968	Estuarine research.
Jacobson Brothers, Inc.:						
Sonar Belle	104	198	4	6	1967	Survey/research.
John E. Chance & Associates, Inc.:						
Gulf Surveyer	100	....	4	8	1968	Survey.
Sea Surveyer	95	....	4	8	1964	Do.
South Pass	65	....	2	4	1957	Do.
Lockheed California Co.:						
Transquest	108	425	10	12	1967	Deep submersible support.
Sea Quest	50	50	2	4	1950	Oceanographic research.
Makapuu Ocean Center (Makai Range, Inc.):						
Westward	100	125	6	12	1961	General research & survey.
Aegir	72	400	6	6	1969	Man-in-the-sea research.
Holokai	70	73	3	8	1968	General research & diver support.
Imua	41	11	3	3	1946	Sea life live capture vessel.
Goodbye Charlie	40	25	2	7	1962	General research & survey.
Mako Products Division of Underwater, Inc.:						
Mako VII	49	16	3	2	1970	Underwater survey support.
Vako V	31	4	3	....	1967	Do.
Marine Acoustical Services:						
F.V. Hunt	185	1,000	18	16	1937	Hydrographic/oceanographic survey.
Paul Langevin	136	500	10	10	1944	Acoustic research.
State Wave (chartered from State Boat Corp.)	125	500	10	10	1965	Do.
State Race (chartered from State Boat Corp.)	110	300	10	8	1966	Survey/research limited oceanography.
A.B. Wood	77	100	7	5	1933	Do.
Marine Contracting International, Inc.:						
Canary	45	25	3	1	1945	Seismic and general survey.
Marine Experimental Services, Inc.:						
Fisherette	42	16	2	6	1947	General research and survey.

APPENDIX G—U.S. OCEANOGRAPHIC SHIPS AND UNDERSEA VEHICLES—Continued

Appendix G-1—U.S. Oceanographic Ships—Continued

C. Industrial/Commercial—Continued

Ship name and designator (if any)	Length (feet)	Tonnage	Crew	Scientists	Year built	Mission
Marine Projects, Inc.:						
Westwind	160	170	8	12	1944	Research/survey.
Sitkin	160	170	8	12	1944	Do.
White Plume	136	259	7	8	1942	Do.
Puffin	136	247	7	8	1942	Do.
Grebe	112	121	5	10	1942	Do.
Warbler	112	122	5	3	1942	Do.
Twanoh	75	47	3	8	1926	Do.
Murre	48	25	2	2	1944	Do.
Martin Vitovesk:						
Fiesta	72	75	4	6	1932	Geophysical surveying.
Mobil Oil Corp.:						
Fred H. Moore	165	197	10	22	1967	Do.
MRI Construction & Diving Corp.:						
Marion	80	69	3	0	...	TVG-seismic survey.
Sea King	42	4	1	0	1950	Diving support.
Constructor	36	7	2	0	1950	TVG-diving support.
Nereus, Inc.:						
Oceanite	34	6	2	5	1964	Survey.
North Carolina State Division of Commercial Sport and Fisheries:						
Dan K. Moore	85	167	7	2	1968	Fisheries research.
Ocean Charter Service, Inc.:						
Machias	70	60	4	4	1962	General research.

Ocean Dynamics Corp.:						
Moon Star	70	55	2	4	1946	Research & survey.
Marietta	55	30	2	4	1950	Do.
Ocean Scallops, Inc., Division of Ocean Science & Eng., Inc.:						
Ruth M.	86	....	15	0	1969	Shellfish research.
Sheela L.	86	....	15	0	1969	Do.
Ocean Science Ships, Inc., Division of Ocean Science & Eng., Inc.:						
Gulfrex	220	920	16	24	1967	Geophysical exploration.
Oceaneer	100	200	6	8	1965	Research/survey.
Wando River	100	150	6	8	1965	Do.
Ogden Technology Laboratories, Inc.:						
Explorer	220	1900	79	23	1940	Education and training.
Perry Submarine Builders:						
Undersea Hunter	85	175	3	6	1968	Submarine Support.
Petty Geophysical Engineering Co.:						
Dabney E. Petty	165	290	9	15	1966	Geophysical survey.
O. S. Petty	165	290	9	15	1968	Do.
Ray Geophysical Division, Mandrec Industries:						
Robray I	165	198	30	....	1967	Seismic exploration.
Jeb Tide	160	190	30	....	1966	Do.
Raytheon Ocean Systems Center:						
Alan	65	60	2	2	1944	Oceanographic/hydrographic surveys.
Reading & Bates Offshore Drilling Co.:						
E. W. Thornton	278	8, 500	47	39	1965	Drilling vessel.
George M. Reading	260	4, 400	40	12	1956	Drilling rig tender.
G. L. Temple	260	4, 400	40	12	1956	Do.
J. W. Bates	260	4, 400	40	12	1956	Do.
J. W. Nickle	260	4, 400	40	12	1956	Do.
Mr. Jack	205	4, 763	43	13	1965	Drilling platform.
Mr. Louie	204	6, 200	46	15	1958	Do.
C. E. Thornton	153	1, 466	38	2	1958	Do.
J. W. Nickle (Mobile)	126	1, 029	......	....	1966	Do.

APPENDIX G—U.S. OCEANOGRAPHIC SHIPS AND UNDERSEA VEHICLES—Continued

Appendix G-1—U.S. Oceanographic Ships—Continued

C. Industrial/Commercial—Continued

Ship name and designator (if any)	Length (feet)	Tonnage	Crew	Scientists	Year built	Mission
Real Eight Co., Inc.:						
Grifon	72	83	4	4	1965	Offshore support and survey.
Derelict	48	19	2		1942	Coastal and harbor support.
Research Charters Corp.:						
Sunbeam	72	72	4	6		General oceanography.
Research Corporation of the University of Hawaii:						
Teritu	90	136	9	6	1935	Oceanographic research.
Reynolds Submarine Service Corp.:						
Privateer	136	250	18	9	1944	Research and survey, engineering.
Rig Tenders, Inc.:						
Rig Builder	165	1, 340	8	27	1966	Offshore mining.
Rig Engineer	165	1, 350	8	45	1967	Offshore support and ocean research.
Rig Pusher	150	1, 185	8	40	1967	Offshore support and supply.
Rig Service	150	1, 195	8	40	1966	Offshore support and ocean research.
Rig Supply	150	1, 205	8	40	1966	Offshore support and supply.
Sea Tender	150	1, 180	8	40	1966	Offshore support and ocean research.
Falcon	90	150	4	11	1963	Oceanographic research.
Seatech Corp.:						
Seatech	23	1	2	2	1967	High-speed ocean research.
Seismic Engineering Co., Division of Whitehall Electronics Corp.:						
Seismic Explorer	165	300	10	16	1967	Geophysical survey.
Seismic Surveyer	165	300	10	16	1967	Do.
Seismographic Service Corp.:						
King Tide	165	190	7	14	1967	Geophysical survey.

Skidaway Institute of Oceanography:						
Evelyn M. III	54	....	2	2–4	1937	Coastal research.
Gray Goose	36	....	2	2	....	Coastal and river research.
Southwest Research Institute:						
Wrangler	46	20	2	3	1952	Research.
State Boat Corp.:						
State Victory	186	1,600	5	25	1970	Complete April 1970; task unassigned.
State Arrow	165	1,300	5	17	1966	Rig service.
State Point	150	1,000	5	15	1965	Search/recovery.
State Express	135	750	5	11	1957	Coring.
State Bell	125	260	5	15	1964	Geophysical.
State Chief	125	260	5	15	1964	Do.
State Wave (chartered to Marine Acous. Serv.)	125	675	5	23	1965	Acoustics.
State Horn	110	250	5	15	1966	Survey/research.
State Race (chartered to Marine Acous. Serv.)	110	250	5	15	1966	Acoustics.
State Key	92	110	5	8	1963	Rig maintenance.
State Gold	87	175	2	4	1968	Shrimping/research.
State Line	87	175	2	4	1968	Do.
State Fair	86	130	5+	12	1957	Diving.
State Jack	86	185	2	4	1969	Shrimping/research.
State Mate	86	185	2	4	1969	Do.
State Star	86	130	5	12	1956	Mothership-submersible.
Teledyne Exploration Co.:						
North Seal	165	299	8	25	1966	Geophysical survey.
Teledox IV	130	200	7	16	1965	Do.
Texas Instruments, Inc.:						
Sea Search	176	190	....	....	....	Geophysical surveying.
R. C. Dunlap	165	1,200	10	16	1966	Geophysical/oceanographic surveying.
Eugene McDermott	165	1,200	10	16	1966	Do.
Baranof	153	....	..	....	....	Geophysical surveying.
Kyle Anne	152					Do.
Cecil H. Green	127	....	6	18	1965	Do.

APPENDIX G—U.S. OCEANOGRAPHIC SHIPS AND UNDERSEA VEHICLES—Continued

Appendix G-1—U.S. Oceanographic Ships—Continued

C. Industrial/Commercial—Continued

Ship name and designator (if any)	Length (feet)	Tonnage	Crew	Scientists	Year built	Mission
Twin Hull Boat Co.:						
Atlantic Twin	90	200	4	10	1965	Research, survey, salvage, fishing.
United Geophysical Corp.:						
Rio Das Contas	135	287	10	18	1957	Geophysical surveying.
United Geo I	125	183	10	18	1966	Do.
United Geo II	125	183	10	24	1966	Do.
United States Underseas Cable Corp.:						
Neptune	494	17,000	80	30	1962	Cable laying ship.
Omega	155	941	22	3	1944	Do.
Vast, Inc.:						
Bittern	145	450	15	5	1955	Research.
Vast Explorer I	140	292	8	6	1965	Research survey.
Q-653	65	27	3	2	1960	Research.
Pelican	45	18	2	1	1960	Do.
Western Geophysical Co. of America:						
Western Beach	150	199	5	19	1966	Geophysical surveying.
Western Sea	150	190	5	19	1966	Do.
Western Shoal	150	199	5	19	1967	Do.
Western Endeavour	127	....	....	....	1970	Do.
Bayou Chico	125	251	4	22	1963	Do.
Dantzler Ash	120	191	4	12	1967	Do.
Miss Freeport	105	149	4	12	1951	Do.
Western Geophysical I	105	189	4	18	1964	Do.
Western Geophysical II	105	188	4	18	1964	Do.

Western Geophysical III	105	188	4	18	1964	Do.
Wayne Walker	100	160	4	14	1957	Do.
F. B. Walker	97	132	4	6	1955	Do.
Western Beacon	97	172	4	18	1965	Do.
Western Crest	97	172	4	18	1965	Do.
Western Gulf	97	172	4	18	1965	Do.
Western Reef	97	172	4	18	1965	Do.
Black Creek	87	151	4	12	1955	Do.
Bluff Creek	87	149	4	12	1953	Do.
Cynthia Walker	87	137	4	8	1955	Do.
Jackson Creek	87	146	4	12	1957	Do.
Oil Creek	87	151	4	14	1955	Do.
Red Creek	87	151	4	12	1955	Do.
Western Offshore Drilling & Exploration Co., Division of Fluor Drilling Services, Inc.:						
Western Offshore No. VII	456	14, 000	....	....	1970	Drilling Barge.
Western Offshore No. III	365	9, 500	48	....	1964	Do.
Western Offshore No. V	365	9, 500	48	....	1966	Do.
Western Offshore No. IV	360	11, 500	48	....	1965	Do.
Western Offshore No. VI	342	5, 265	48	....	1968	Do.
Western Offshore No. II	280	5, 430	48	....	1962	Do.
Western Offshore No. I	252	3, 220	48	....	1960	Do.
Caldrill No. I	176	299	28	....	1964	Self-propelled core drilling vessel.
Exploit	174	298	20	....	1965	Do.
Nesco No. 1	136	280	12	....	1965	Research vessel.
Westinghouse Electric Corp., Ocean Research Laboratory:						
Search Tide	156	450	4–5	19	1967	Submersible tender.

* No attempt has been made to differentiate between "ships" and "boats" on the basis of size. The agencies, institutions, and individuals contacted for purposes of this inventory were asked to identify those vessels which are engaged in productive oceanographic work.
[1] Scheduled for 1970 retirement.
[2] Rebuilt 1970.
[3] Conversion date.

APPENDIX G—U.S. OCEANOGRAPHIC SHIPS AND UNDERSEA VEHICLES—Continued

Appendix G-2—U.S. Undersea Vehicles*

Submersible name	Year built	Length (feet)	Weight (1000 lbs)	Design depth range (1000 ft)	Payload (100 lbs)	Personnel (crew, observers)	Life support endurance (man-hours)	Owner/operator
Aluminaut	1965	51	146	15	40	3–4	336–504	Reynolds Submarine Services Corp.
Alvin	1965	23	31.6	6	3.5	1–2	24–30	U.S. Navy/Woods Hole Oceanographic Institution (not operational).
Amersub 300 (Sportsman)	1961	14	2.5	0.3	4.5	2	8–10	20–22 of the 30 Amersubs built, of both.
Amersub 600 (Sportsman)	1963	13	3.5	0.6	7.0	1–1	8–16	Classes, are in use by miscellaneous operators.
Asherah	1964	17	9.5	0.6	1.8	1–1	44	Technoceans, Inc.
Auguste Piccard (PX–8)	1964	94	328	2.5	200	5–35	48	Chicago Bridge & Iron Corp.
Beaver Mark IV (Roughneck)	1968	24	28	2	14	2–2	48–144	North American Aviation.
Ben Franklin (PX–15)	1968	48	286	2	85	3–3	4320–6048	Grumman Aircraft Engineering Corp.
Benthos V	1963	11.3	4.2	0.6	4	3	8–16	Lear Siegler Inc.
Ceptor I	(1)	20	6.5	2.0	....	2	30	Brooks Institute.
Deep Diver (PLC 4)	1967	23	16.5	1.3	20	1–3	8	Perry Oceanographics, Inc.
Deep Quest	1967	40	110	8	70	2–2	192	Lockheed Missiles & Space Co.
Deep Six	......	16	5.9	0.15	10	1–2	36	Deep Six Marine Service.
Deep Star 2000	1970	20	18	2	5	1–2	36–144	Westinghouse Electric Corp.
Deep Star 4000	1965	18	18	4	3.5	1–2	12–48	Westinghouse Electric Corp.
Deep Star 20,000	(1)	36	80	20	15	1–2	64	Westinghouse Electric Corp.
Deep View	(1)	15.6	6	1.5	3	3	2–8	U.S. Navy/NURDC.
Dolphin (AG SS–555)	1968	152	1860	10	....	22	....	U.S. Navy/SUBLANT.
Dowb	1968	17	19.5	6.5	1.5	2–1	195	AC Electronics Div., General Motors Corp.
Dredge (SEAPOD)	1969	....	....	0.1	....	2	Tethered	Ocean Dredging, Inc. (Subsidiary of Ocean Science & Engineering).
DSRV I	1970	49.3	70.7	5	....	3–24	48	U.S. Navy/SUBDEVGRU ONE (undergoing tests).

DSRV II	(1)	49.3	70.7	5	....	3–24	48	U.S. Navy/SUBDEVGRU ONE.
Guppy (Tethered)	1970	11	5	1	8.5	1–1	24–96	Sun Shipbuilding & Dry Dock Co.
Kittridge Sport Sub	......	10	2.2	0.1	....	1	1.5	Vast, Inc. (formerly Kittridge Sport Subs, Inc.) (11 Built).
Kumukahi	1969	6	3.7	0.3	0.5	2	8	Oceanic Fondation (Makai Range).
Mako (*Amersub 300*)	1969	14	1.25	....	....	2	....	Underwater, Inc., Mako Products Division.
Martin U–9	1967	7	1	0.3	....	1	....	Marine Resources Inc.
Mini Diver MD–1	1968	16	4	0.25	3	2	3–9	Great Lakes Underwater Sports, Inc.
Nautilette	......	12	2	0.1	....	1–2	1	Nautilette, Inc. (Various Models Constructed).
Nekton	1968	15	4.5	1.0	0.5	1–1	10–48	General Oceanographics Inc.
NEMO (Naval Exp. Manned Obs.).	(1)	6	1.5	0.6	....	1–1	16–48	U.S. Navy/Naval Civil Engineering Lab.
NR–1	1969	137	740	....	....	......	....	U.S. Navy/SUBFLOT TWO.
PAULO I	1968	13.5	5.2	0.6	2.0	1–1	24–48	Anautics, Inc.
PC3–X (Gaspergou)	1962	20	4.8	0.15	7.5	2	20	University of Texas (Defense Research Labs).
PC3–A	1962	18.5	5.3	0.3	7.5	2	20	U.S. Army/Kentron Hawaii Ltd.
PC3–A	1962	18.5	5.3	0.3	7.5	2	20	U.S. Air Force/Kentron Hawaii Ltd.
PC3–B	1963	22	6.0	0.6	7.5	1–1	12–18	Perry Oceanographics, Inc.
PC3–B (Techdiver I)	1964	22	5.5	0.6	7.5	1–1	12–18	International Underwater Contractors, Inc.
PC5–C (NAPA)	1967	22	11	1.2	3	1–1	12–18	Pacific Submersibles Inc./Perry Oceanographics, Inc.
PC8–C	(1)	22	21	1.0	....	3	....	(For Perry Oceanographics, Inc.).
PC9–C	(1)	22	21	1.2	....	3	....	(For Brown & Root, Inc.).
Pisces I	1966	16	15.0	1.8	10	2–1	18–76	Hyco International Eng., Inc.
Pisces III	1969	20	25	3.3	13	2–1	18–76	Do.

See footnotes at end of table.

APPENDIX G—U.S. OCEANOGRAPHIC SHIPS AND UNDERSEA VEHICLES—Continued

Appendix G-2—U.S. Undersea Vehicles *—Continued

Submersible name	Year built	Length (feet)	Weight (1000 lbs)	Design depth range (1000 ft)	Payload (100 lbs)	Personnel (crew, observers)	Life support endurance (man-hours)	Owner/operator
Recoverer I	......	....	....	1.0	....	......	....	International Underwater Research Corp.
Sea Cliff	1970	25	44.0	6.5	3.5	1–2	24–30	U.S. Navy/Woods Hole Oceanographic Institution.
Sea Ray (SRD–101)	1967	20.5	8.9	1.0	0.5	2–1	4–24	Submarine Research & Development Corp.
Sea Link	([1])	....	....	3.0	....	......	....	Edwin A. Link. (Diver lockout capability)
Shelf Diver (PLC4–B)	1968	23	17	0.8	12	1–3	40–60	Perry Oceanographics, Inc.
Snooper	1969	11.6	4.1	1	2	1–1	10–12	Sea Graphics.
Star II	1965	17.8	10.0	1.2	5	1–1	42–48	General Dynamics/Electric Boat.
Star III	1966	24.8	20	2.0	9.7	1–1	120–126	General Dynamics/Electric Boat.
Submanaut	1956	49.0	108	0.6	45	2–6	48	Submarine Services, Inc.
Submanaut	1964	9.5	5.5	0.2	2	4	2–6	Helle Engineering, Inc.
Submaray	1965	13	3.2	0.3	1.5	2	2–16	Kinautics International, Inc.
Swedish Military Submarine Conversion.	1970	200	2000	0.4	....	22	....	Marine Resource Consultants, Inc.
Transparent Hull Submersible (THS) (I)	([1])	18.7	....	0.6	....	1–1	36	U.S. Navy/NUC
Trieste II	1965	78.5	156	20	20	1–1	12–24	U.S. Navy/SUBDEVGRU ONE.
Turtle	1970	25	44	6.5	3.5	1–2	24–30	Do.
Viper Fish	......	....	....	....	....	......	....	Daniel S. Taylor.

*Submersibles engaged in research activities, in contrast to vehicles for recreational uses.

[1] Under construction.

APPENDIX H—BREADTH OF TERRITORIAL SEAS AND FISHING JURISDICTIONS CLAIMED BY SELECTED COUNTRIES

Country	Territorial sea	Fishing limit	Other
Albania	10 miles	12 miles	
Algeria	12 miles	12 miles	
Argentina		200 miles	Sovereignty is claimed over a 200-mile maritime zone but the law specifically provides that freedom of navigation of ships and aircraft in the zone is unaffected. Continental Shelf—including sovereignty over superjacent waters.
Australia	3 miles	12 miles	
Belgium	3 miles	12 miles [1]	
Brazil	12 miles	12 miles	
Bulgaria	12 miles	12 miles	
Burma	12 miles	12 miles	
Cambodia	12 miles	12 miles	
Cameroun	18 miles	18 miles	
Canada	3 miles	12 miles	
Ceylon	6 miles	6 miles	Claims right to establish conservation zones within 100 nautical miles of the territorial sea.
Chile	3 miles	200 miles	
China	3 miles	3 miles	
Colombia	12 miles	12 miles	
Congo (Brazzaville)			
Congo (Kinshasa)	3 miles	3 miles	
Costa Rica	3 miles		"Specialized competence" over living resources to 200 miles.
Cuba	3 miles	3 miles	
Cyprus	12 miles	12 miles	
Dahomey	12 miles	12 miles	100-mile mineral exploration limit.
Denmark	3 miles	12 miles [1]	
Greenland		12 miles	
Faroe Islands		12 miles	
Dominican Republic	6 miles	12 miles	Contiguous zone 6 miles beyond territorial sea for protection of health, fiscal, customs matters, and the conservation of fisheries and other natural resources of the sea.
Ecuador	200 miles	200 miles	
El Salvador	200 miles	200 miles	

See footnote at end of table.

APPENDIX H—BREADTH OF TERRITORIAL SEAS AND FISHING JURISDICTIONS CLAIMED BY SELECTED COUNTRIES—Continued

Country	Territorial sea	Fishing limit	Other
Ethiopia	12 miles	12 miles	
Federal Republic of Germany.	3 miles	12 miles [1]	
Finland	4 miles	4 miles	
France	3 miles	12 miles	
Gabon	12 miles	12 miles	
Gambia	3 miles	3 miles	
Ghana	12 miles	12 miles	Undefined protective areas may be proclaimed seaward of territorial sea, and up to 100 miles seaward of territorial sea may be proclaimed fishing conservation zone.
Greece	6 miles	6 miles	
Guatemala	12 miles	12 miles	
Guinea	130 miles	130 miles	
Guyana	3 miles	3 miles	
Haiti	6 miles	6 miles	
Honduras	12 miles	12 miles	
Iceland	4 miles	12 miles	
India	12 miles	12 miles	Plus right to establish 100 miles conservation zone.
Indonesia	12 miles	12 miles	Archipelago concept baselines.
Iran	12 miles	12 miles	
Iraq	12 miles	12 miles	
Ireland	3 miles	12 miles [1]	
Israel	6 miles	6 miles	
Italy	6 miles	12 miles [1]	
Ivory Coast	6 miles	12 miles	
Jamaica	12 miles		
Japan	3 miles	3 miles	
Jordan	3 miles	3 miles	
Kenya	12 miles	12 miles	
Korea	3 miles	20 to 200 miles.	Continental Shelf including sovereignty over superjacent waters.
Kuwait	12 miles	12 miles	
Lebanon		6 miles	
Liberia	12 miles	12 miles	
Libya	12 miles	12 miles	
Malagasy Republic	12 miles	12 miles	
Malaysia	12 miles	12 miles	
Maldive Islands	3 miles	6 miles	
Malta	3 miles	3 miles	
Mauritania	12 miles	12 miles	
Mauritius	3 miles	3 miles	
Mexico	12 miles	12 miles	
Morocco	3 miles	12 miles	Exception—6-mile fishing zone for Strait of Gibraltar.
Netherlands	3 miles	12 miles [1]	
New Zealand	3 miles	12 miles	
Nicaragua	3 miles	200 miles	Continental Shelf including sovereignty over superjacent waters.

See footnote at end of table.

APPENDIX H—BREADTH OF TERRITORIAL SEAS AND FISHING JURISDICTIONS CLAIMED BY SELECTED COUNTRIES—Continued

Country	Territorial sea	Fishing limit	Other
Nigeria	12 miles	12 miles	
Norway	4 miles	12 miles	
Pakistan	12 miles	12 miles	Plus right to establish 100-mile conservation zones.
Panama	200 miles	200 miles	Continental Shelf including sovereignty over superjacent waters.
Peru	200 miles	200 miles	
Philippines			Archipelago concept baselines. Waters between these baselines and the limits described in the Treaty of Paris, Dec. 10, 1898, the United States-Spain Treaty of Nov. 7, 1900, and United States-United Kingdom Treaty of Jan. 2, 1930, are claimed as territorial sea.
Poland	3 miles	3 miles	
Portugal	No claims	12 miles [1]	
Romania	12 miles	12 miles	
Saudia Arabia	12 miles	12 miles	
Senegal	12 miles	18 miles	Fishing zone beyond 12 miles does not apply to those nations which are party to the 1958 Geneva Convention on the Territorial Sea and the Contiguous Zone.
Sierra Leone	12 miles	12 miles	
Singapore	3 miles	3 miles	
Somali Republic	12 miles	12 miles	
South Africa	6 miles	12 miles	
Spain	6 miles	12 miles [1]	
Sudan	12 miles	12 miles	
Sweden	4 miles	12 miles [1]	
Syria	12 miles	12 miles	Contiguous zone—an additional 6-mile area to control security, customs, hygiene, and financial matters.
Tanzania	12 miles	12 miles	
Thailand	12 miles	12 miles	
Togo	12 miles	12 miles	
Trinidad and Tobago	3 miles	3 miles	
Tunisia	6 miles	12 miles	Fisheries zone follows the 50-meter isobath at specified areas of the coast (maximum 65 miles).
Turkey	6 miles	12 miles	
Ukrainian S.S.R	12 miles	12 miles	
U.S.S.R	12 miles	12 miles	
United Arab Republic	12 miles	12 miles	
United Kingdom	3 miles	12 miles	
Overseas areas	3 miles	3 miles	
United States of America	3 miles	12 miles	

See footnote at end of table.

APPENDIX H—BREADTH OF TERRITORIAL SEAS AND FISHING JURISDICTIONS CLAIMED BY SELECTED COUNTRIES—Continued

Country	Territorial sea	Fishing limit	Other
Uruguay	12 miles	200 miles	Sovereignty is claimed over a 200-mile maritime zone but law specifically provides that the freedom of navigation of ships and aircraft beyond 12 miles is unaffected by the claim.
Venezuela	12 miles	12 miles	
Vietnam	3 miles	20 kilometers. (10.8 miles)	
Yemen	12 miles	12 miles	
Yugoslavia	10 miles	10 miles	

[1] Parties to the European Fisheries Convention which provides for the right to establish 3-mile exclusive fishing zone seaward of 3-mile territorial sea plus additional 6-mile fishing zone restricted to the convention nations.

Source: Information available to the National Council on Marine Resources and Engineering Development as of Jan. 1, 1970.

U.S. GOVERNMENT PRINTING OFFICE: 1970 O—373-378